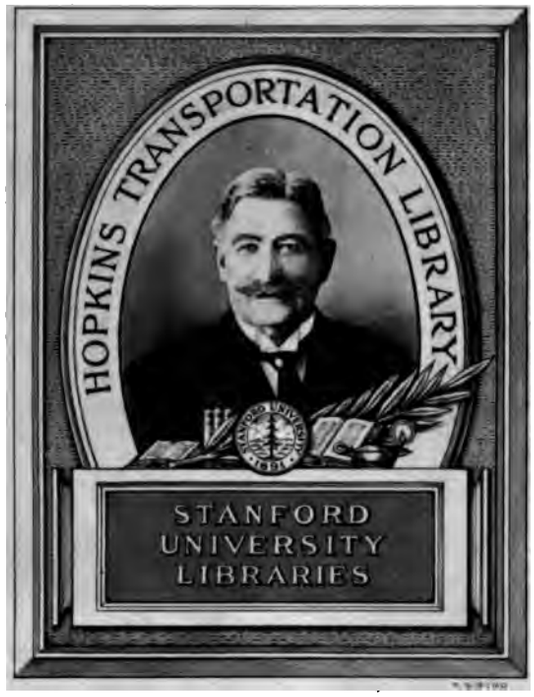
PNEUMATIC
RAILWAYS

YALLANCE

1833.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A

# LETTER

TO

## THE KENSINGTON CANAL COMPANY,

ON THE

SUBSTITUTION OF THE PNEUMATIC RAILWAY
FOR THE COMMON RAILWAY

BY WHICH THEY CONTEMPLATE EXTENDING THEIR LINE OF CONVEYANCE.

BY JOHN VALLANCE.

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PRINTED BY ORDER OF THE COMPANY.

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LONDON:
GEORGE WIGHTMAN, 24, PATERNOSTER ROW.

1833.

" Under circumstances of this sort, there can be no doubt that those microcosmic minds, which, habitually occupied in the consideration of what is little, are incapable of discerning what is great, and who already stigmatise the proposition as a romantic scheme, will, not unsparingly, distribute the epithets—absurd, ridiculous, chimerical. The commissioners must, nevertheless, have the hardihood to brave the sneers and sarcasms of men who, with too much pride to study, and too much wit to think, undervalue what they do not understand, and condemn what they cannot comprehend."

*Report on the Practicabi lity of the Erie and Hudson Canal.*

J. S. Hodson, Printer, Cross Street, Hatton Garden.

# A LETTER, &c.

My Lord and Gentlemen,

THE contemplated addition of a railway to your line of conveyance, induces me to solicit the honour of your attention to a method of effecting your object, which may, perhaps, prove the cheapest and best you can adopt.

From the statements of the gentlemen who gave explanations on the subject at the meeting, your object appears to be, to effect some method of communication between your basin at Kensington, and some point of the Grand Junction Canal, and the proposed London and Birmingham Railway, which may enable you, either to take advantage of the Grand Junction Canal as a channel to convey and receive goods to and from, or of the proposed railway to Birmingham; so that you may be able to convey passengers to and from that railway, and to and from the western parts of town, should it be put into operation.

Your present line being a water line, I should, were it not for the intervention of the high ground which is between your basin and the Grand Junction Canal, recommend the extension of this water line; because an additional expenditure of 900*l.* or 1000*l.*, to provide a couple of the gigs by which passengers are now conveyed at the rate of ten or twelve miles an hour along the Paisley and Ardrossan Canal, would then enable you to carry any number of passengers to and from the Birmingham Railway considerably faster, and many times cheaper, than omnibuses, &c. &c. would convey them to and from the town end of that railway.

But as the numerous locks, which the height of that ground renders necessary, would occasion the loss of all the time which the newly-discovered method of rapid conveyance on canals might save, the extension of your present line appears to be incompatible with your object of rendering such extension adapted to the rapid conveyance of passengers, as well as goods at the usual rate.

This impediment is not, however, the only circumstance which would make me pause in recommending the extension of your canal. It is publicly stated that the estimated expense of extending your canal the two and a half miles you contemplated was 150,000*l.*; while this would not be the sole expense attending it.

Owing to there being no water to supply the waste of the numerous locks which you must construct, to raise barges to the height you wish to surmount, you would have, in addition to extending your canal, to be also at the expense of laying down large water-pipes all along it; and of erecting steam-engines, and pumps, to raise *up* from the Thames, every drop of the water you would require to lower your barges *down* to it. The first cost of doing this would be very considerable: since,

in addition to the steam-engines, pumps, and two and a half miles of large pipe which you must lay down, you must also be at the expense of purchasing ground at the end of your proposed extension, for the site of, and excavating the earth to form, a large reservoir, for the water to be pumped up into to supply the locks.

Great, however, as would be the first cost of thus providing water to work the proposed extension of your canal, yet would this first cost be less important than the current expenses of it; since for every barge that passed through your canal, you would have to pump above two hundred tons of water, nearly 100 feet high: than which, nothing can be conceived more contrary to principles of economy; it being tantamount to having to lift a *whole* hundred weight up, every time you extended your hand to put a *quarter* of a hundred weight down. Were it necessary that those two hundred tons of water should be pumped *only* when you *raised* a barge *up* with (or by means of) them, it would not be so vexatious.

But to be forced to pump two hundred tons *up*, in order to float the smallest load a barge carries* *down* your canal, would be so contrary to all principles of economical conveyance, as well as costly, that it becomes unavoidable to seek for some other means of transmission.

That which first struck you as applicable to your object, was a rail-way; since, by means of it, passengers may be conveyed as well as goods; so that, should any circumstance connected with the London and Birmingham Railway ever render it desirable, you might, then, convey passengers along your line. But though this could certainly be done, yet would the attainment of that certainty be attended with an expense, which might prove greater than the value of the purchase.

The avoidance of ascents which are at all abrupt, is now stated to be of such consequence as relates to the diminution of the daily expenses of railways, and so important with respect to what locomotive engines can do upon them, that it is current as the dictum of the principal engineer of the London and Birmingham Railway, that it is better to lay down six miles of railway to avoid (by going round it) a rise of 174 feet in one mile (an ascent of about an inch in a yard, that is) than to carry one mile of railway over said rise. And the junior engineer to that railway stated before the Lords' Committee, that for a locomotive engine to get over a rise of fifty feet in height, was "nearly equal to going four miles round."

The fuel consumed being the principal item of expense in locomotive engines, and the price of fuel with you being nearly ten times greater than on the Liverpool and Manchester line†, the attainment of the desideratum of as regular an ascent as can be procured, becomes, according to this doctrine, more important as relates to your line, than it would be where fuel was cheaper, in proportion to the dearness of that fuel. A regular plane of ascent may, therefore, be considered indispensable to the proper operation of any railway you might lay down.

Were you to do the utmost that could be done towards obtaining this regular plane of ascent, between your proposed points of departure and arrival, by cutting and embanking so as to make

* I have known a barge of (apparently) fifty tons burthen, come up the whole length of your canal, with nothing but fourteen tons of coal to land at your basin.

† In his Report on the Liverpool and Manchester Railway, Mr. Walker states the price of the 40,000 tons of coal, which he supposed might be required for the locomotive engines, at 5*s*. 10*d*. per ton. The 25,000 tons which he supposed might be required for the stationary engines, he states at the price of 2*s*. 6*d*. per ton.

In their review of this Report, Messrs. Stephenson and Locke state the price of coal at 4*s*. 6*d*. per ton for 37,222 tons.

your line one continuous inclined plane, it would still be so remote from a level, as to rise at the rate of one foot of perpendicular height for 154 feet of horizontal distance; which would make the power required to draw any load along your line nearly twice as great as that which would be requisite to draw the same load on a level; while it would also present a sharper rise than some railways where stationary engines are the only moving power employed, owing to locomotives being considered unfit for railways so inclined.

Supposing your line, which must have the same number of rails that the Birmingham Railroad is to have (two lines of *way* that is) to be no wider than that railway is to be in the narrowest part, the amount of embanking necessary to render your plane of ascent regular to this degree would not be so little as one million of cubic yards.

In the evidence before the Lords' Committee on the London and Birmingham Railway it is stated, that on the Liverpool and Manchester Railway there are about three millions of cubic yards of cuttings and embankments. It being known that the money paid by that Company for this purpose has exceeded two hundred thousand pounds, it may be presumed that the expense of one third of that amount of cutting and embanking on your line would not be less than about 70,000*l.*; while, as the nature of the ground your line must pass through, would render the proportion of embankments much greater than that of excavations, this amount of 70,000*l.* would be added to, by your being actually compelled to purchase the earth *itself* which would be required for those embankments, as well as to pay for the labour of digging and conveying it to where you wanted it.

Long lines of work being done for much less expense *per mile* than short ones; the London and Birmingham Railway being a very long line (112½ miles); the engineers of that railway having the very highest reputation as railway engineers; and the estimates laid before Parliament by those gentlemen for that railway, being the best authority it is possible to refer to as relates to the probable cost of a railway—I shall, for these reasons, and in order to prevent your supposing that my own opinion affects my statement, advert to the anticipated expense of that railway *per mile* as a measure of the cost of yours.

Deducting the estimated expense of cutting and embanking, from the *general* estimate of the London and Birmingham Railway, the average estimated expense of the *other* work of the *two* lines of way now proposed for that road (instead of the *four* lines of which it was to consist) is 20,631*l.* per mile.*

And as it is not evident why your *short* line should be done for *less comparative* expense than this long one (while it is to be presumed that it would cost much more), it may be assumed that the actual expense of attempting to make a railway, on which the tractive force required for any load

* The capital requisite to complete this railway was first announced to be a million and a half. Then it was raised to two millions. Then it was raised to three millions, in order to admit of a "quadruple line" (that is, eight lines of rails,) being laid down. And credit is now taken for its *cheapness*, because, after announcing that three millions would be sufficient to lay down a "quadruple" railway, two millions and a half are stated as the *estimated* expense of a "double" railway. That is, after having, by advertisement upon advertisement, announced that three millions would be enough to lay down eight lines of rails, credit is taken for finding out that four lines will cost two millions and a half: when the fact is, that the estimated expense is reduced only one-sixth, while the work which said three millions were stated to be enough to do, is reduced one half. In other words, twopence-halfpenny is charged for *half* the loaf, after it had been, in every possible way trumpetted forth, that the *whole* loaf would be sold for threepence: while even this twopence-halfpenny is liable to additions such as the following pages advert to.

would be nearly twice as great as on a level, along the line you propose, would not be so little as 100,000*l.*

And, supposing that you should be willing to adopt the less favourable method of railway transmission—i. e. levels and steep inclined planes, with fixed engines on the summits—still might not expense be very greatly reduced?

The original estimate of the Liverpool and Manchester Railway was 400,000*l*, about 12,000*l.* per mile that is; with respect to which the Quarterly Review for March 1825 says: "The estimate "for the Liverpool and Manchester Railway we have understood to be taken at 12,000*l.* per mile. "But that road is meant to be executed on a magnificent scale; to be sixty-six feet wide*; the rails "to be laid down in the best possible manner; and the purchase of land at the extremities must be "paid for at an enormous price. This estimate also includes the cost of engines, waggons, and "warehouses."

Most unwisely, however, as well as untruly, the advocates of railways attempt to deny, that the original estimate for the Liverpool and Manchester Railway was so low as this, or that it included the "cost of engines, waggons, and warehouses;" in order to show that the actual cost of the railways now contemplated will not exceed *their* estimated expense, as the actual cost of the Liverpool and Manchester Railway has exceeded that estimate. For the facts of the case I appeal to the original prospectus of the Liverpool and Manchester Railway, dated October 29, 1824; the 5th paragraph of which document is as follows:—

"The ground has been surveyed by eminent engineers, and the estimated expense of a rail-"road upon the most improved construction, *including the charge for locomotive engines to be* "*employed upon the line, and other contingencies*, is 400,000*l.* which sum it is proposed to raise in "4000 shares of 100*l.* each."

It cannot, therefore, but be contrary to good sense as well as fact, for the advocates of railways to attempt to deny evidence of this nature.

The first line of the credit side of the account given in to the Lords' Committee on the proposed London and Birmingham Railway, by the Treasurer of the Liverpool and Manchester Railway, on the 24th June last, stands thus: "By amount expended (up to the 31st December, 1831) in com-"pletion of the ways and works, 992,054*l.* 3*s.* 6*d.*": while the same document says, "By the "additional number of locomotive engines and carriages that will be required for the increased "number of departures, and especially by the outlay of capital for the construction of the new "tunnel, and the unavoidable cost of warming, lighting, and working the same, the Company will "incur an increased annual expenditure, which will be very inadequately compensated by the "saving of the charge for omnibuses." Now, as exclusive of this "additional number of loco-

* I believe that the average width is not the half of 66 feet: and that it is, in parts, *much* less than half, is proved by various circumstances; one of which is the following account of an "Accident on the railway.—An accident fatal to a "poor man named Thomas Ryans, took place on the railway on Monday last. Ryans was employed by the Railway "Company as a breaksman; and was engaged in his business on a small train of goods drawn by the Vulcan engine. "When within a short distance of a bridge, he, for some purpose, projected his head over the side of the waggon, and, "melancholy to relate, it came in contact with the buttress of the bridge. The poor fellow's brains were knocked out "on his cheek; but he lingered some time before death ended his sufferings.—*Manchester Courier.*"—*Morning Herald*, 27th Sept. 1831.

" motive engines and carriages that will be required," the expense of making this tunnel is estimated at 130,000*l.*—while, if the degree to which the actual cost of the railway itself exceeded its estimated expense, be taken as a rule, the actual cost of this tunnel may be nearer 400,000*l.* than 130,000*l.*—and, as the following extract from the pamphlet entitled " Remarks on the Birmingham and London Railroad, by Investigator," shews that an important item has been omitted, the *whole* expense of the Liverpool and Manchester Railway, up to the 31st December, 1831, will, it appears, exceed 1,200,000*l.* which is above 40,000*l.* per mile.

" There is a most important item entirely omitted in the treasurer's account. Nearly 740,000*l.* were expended previous to May, 1830, all of which has now been expended for nearly one year, and different portions of it in different years, the first six years ago; not one shilling has yet been returned back again; and, therefore, the amount must be increased by the interest on the successive sums expended.

" We shall not fatigue our readers with the details; but the following abstract is very near the truth :—

| | £. | £. | *s.* | *d.* |
|---|---|---|---|---|
| Interest of | 20,397 | 7,034 | 0 | 0 |
| Ditto | 20,397 | 5,629 | 0 | 0 |
| Ditto | 100,000 | 21,212 | 0 | 0 |
| Ditto | 181,061 | 28,868 | 0 | 0 |
| Ditto | 199,240 | 20,925 | 0 | 0 |
| Ditto | 739,165 | 11,823 | 0 | 0 |
| | Total (underrated) | 95,491 | 0 | 0 |

" Omitting the odd hundreds, as we wish to be under, rather than to exceed the truth, there must, therefore, be 95,000*l.* allowed for interest."

Supposing, therefore, that you were to diminish the expense of levelling, by adopting the system of steep inclined planes, with stationary engines on the s ummits of them, todrag the loads up by means of ropes, &c., according to the usual course of the stationary engine system, expense might not be very greatly reduced. Since it appears, from the accounts laid before Parliament, that, deducting the money paid for cutting and embanking on the Liverpool and Manchester Railway, as well as the 130,000*l.* of additional expenditure, which I have just mentioned, the actual cost of that railway, *exclusive of cuttings and embankments*, has really been so high as to amount, very nearly, to 29,000*l.* per mile.

Even, therefore, if there were not a single yard of cutting and embanking to be done on your line, the estimated expense of the London and Birmingham, and the *actual* cost of the Liverpool and Manchester Railway, bid you prepare yourselves for an outlay of not less than 20,000*l.* per mile; while the money actually paid on the latter, may well make you anticipate that it would be nearer 30,000*l.* per mile; and this, as has just been stated, *exclusive* of the expense of cuttings and embankments.

There are persons who will deny this. But instead of occupying your time by entering on any discussion of the question here, I will merely refer you to the paragraph quoted on the last page from the *original* prospectus of the Liverpool and Manchester Railway, and to the following passage

from the *second* prospectus issued by that company on the 26th December, 1825, when the capital was raised to 510,000*l.* instead of 400,000*l.*,—that is, to 17,000*l.* per mile, instead of 12,000*l.*

"A very prominent objection taken by the opponents of the bill, was founded on the errors in "the section and levels, as exhibited before Parliament. These errors, the Committee at once "acknowledged and regretted; and, to avoid all chance of similar complaint in future, they have "engaged the professional services of *most eminent engineers*, aided by assistants of undoubted "talents and activity; whose combined efforts justify the fullest assurance, not only of the "correctness of the plans and sections, but that the whole line will be laid and arranged with that "skill and conformity with the rules of mechanical science, which will equally challenge approbation, "whether considered as a national undertaking of great public utility, or as a magnificent specimen "of art."

Yet, notwithstanding the "undoubted talent" of those "most eminent engineers," and their "assistants," whom the Committee had thus "engaged," the actual cost of the Liverpool and Manchester Railway, has *more* than doubled the sum which the "undoubted talent" of those engineers and their assistants estimated it would cost, on the *second* survey of the line.

The objections, therefore, of those who will say that I overrate the expense of a railway, may not be more consistent with fact, than the *under* estimate of these "most eminent engineers," and their "assistants of undoubted talents and activity:" while if, after being a *second* time surveyed and estimated, the Liverpool and Manchester Railway cost a million and a quarter, instead of the half million to which the revised and reconsidered estimates of these "most eminent engineers" and their "assistants of undoubted talent and activity," raised it, it becomes a simple rule of three question to estimate how much the London and Birmingham Railway will cost, above the two and a half millions, which it is now stated will complete the double line that is to be laid down, instead of the quadruple line which was stated to cost three millions. Of the four sums which this railway has been estimated to cost (one and a half millions; two millions; three millions; and two and a half millions; vide note on page 5), nobody can tell which will be right; though there are those who have publicly stated (and staked their critical accuracy on its correctness), that the whole four added together, will not be much more than enough.

It is true, that by having three *very* sharp *indeed* inclined planes, of eight or ten feet perpendicular ascent each, an almost perfect level might, without very great expense for cutting and embanking, be obtained for four-fifths of your line to the Grand Junction Canal: while, by availing myself of an ascending power possessed by locomotive engines, which has (to my very great surprise) hitherto been overlooked, not only by railway engineers in general, but also by the inventors and improvers of locomotive engines*, I could get your engines and their loads up these ascents without any difficulty. But as the rise, during the sixty feet (nearly), of ascent, which must be surmounted in the remaining fifth of your line to the Grand Junction Canal, must be at the rate of one in forty-seven; as the power required to get the loads you must be prepared to send up that ascent,

* Mr. Badnall's recent patent may make it advisable to state that this paragraph, as well as the far greater part of the Letter, was written prior to, and got ready for delivery at a meeting of the Kensington Canal Company, which was fixed for the 26th of September, 1832. Owing, however, to this meeting having been deferred, *sine die*, by an advertisement in the *Times* of the 21st of that month, opportunity has been given for additions; though the paragraph to which this note refers, has neither been added to, nor altered, since it was first written.

at the rate you must also be prepared to *raise* them, will, including the friction, &c., of the ropes, render it necessary that the stationary engines should, each of them, be, roundly speaking, 150 horses power—in consequence of these things, and owing to the delay and danger attendant on the steep inclined plane and stationary engine system, as well as for the following reasons, this conjoint method of levels and steep inclined planes, and of locomotive and stationary engines, might be little better for you than making one continuous inclined plane of your line; so as to admit of locomotives running over the whole of it; and, consequently, not needing stationary engines at all.

Notwithstanding the efficacy of steep inclined planes with stationary engines on the summits, where they are absolutely unavoidable, yet are they so objectionable where it is any how possible to avoid them, that the engineers of the London and Birmingham Railway have recommended cuttings and embankments to the amount of twenty-three millions of cubic yards (nearly) in order to avoid them; while evidence makes it appear, that the Liverpool and Manchester Railway Company prefer keeping extra locomotives waiting at the foot of their inclined planes, to draw the trains up, rather than use the stationary engines, which, it has been stated, they fixed at the top of those ascents for that purpose.

But these general objections against steep inclined planes and stationary engines, are not the only ones which would operate to the rejection of this method on your proposed line.

To connect it with the London and Birmingham Railway, it must either be carried over the Grand Junction Canal, or the London and Birmingham Railway must be brought across that canal to come to it; and as it may be divined that Mahomet must go to the mountain, rather than that the mountain should come to Mahomet, it may be concluded that your crossing the canal is unavoidable; especially when it is considered that bringing the Birmingham Railway over to the south side of the canal, would render necessary a *second* crossing of it, in order to take that railway back to the north side again. And as, exclusive of the expense of the wide bridge, you must provide to carry your line of railway across the canal, it would cause, first, a second break, or variation, in your method of draught, by compelling you, after taking the loads from the locomotive engines which brought them from your basin to the foot of the ascent, and getting them up that ascent by means of the stationary engines, either to have other stationary engines adjoining the Birmingham line, to get the loads from the canal to that line, or else to transfer them for that purpose from the stationary engines, to locomotives again; while, secondly, and in addition to this, there would be the objection and opposition of the Grand Junction Company, to the large stationary engines and buildings which you must erect close to their canal to be overcome, it would appear that a method which should avoid the, perhaps, fatal objections, and certainly most enormously expensive Parliamentary opposition of the Grand Junction Company to the proposed extension of your line, would be a desideratum.

In addition to this, there must be the breadth of land required for a railway; which, looking at the width necessary for the embankments, would, considering the value of the ground through which your line must run, render the surface purchase (comparatively) equally expensive as the cutting.

Mere expense of purchase, might not, however, be the principal objection to a railway along the line you contemplate.

According to the section of that line, the height of the embankment it would be necessary to raise to give you a regular plane of ascent, would so effectually divide the grounds you passed through, as to prevent your bridging across such embankment for private roads, and compel you to "tunnel" under your own line, in order to admit of communication between the divided properties you would intersect; while, in the more level part, considerable expense for bridging across it for the same purpose might be necessary. And let you do the utmost that could be done, to inconvenience landowners and occupiers as little as possible, it is impossible to avoid giving them *real* cause for objection on this ground, for the reasons pointed out in the following extract from a publication on the London and Birmingham Railway. "Parts of estates and of fields will also be separated from "each other, by immense gashes and mounds; over and under which expensive bridges, and long "and wide tunnels, must either be constructed, or the value of the land must be still further "deteriorated. Granting these to be constructed (and they too would be an expense as great as "the other), they would not be an adequate compensation; for the passing and repassing of the "numerous flocks and herds by them, would completely trample down and ruin the adjacent fields. "There will also be cutting of the veins that contain water; the springs and ponds will in conse-"quence be dried, and many of the sloping fields adjoining the line so deprived of water, that they "will either become unfit for the purposes of pasturage, or the stock will have to be driven to "a distance for a supply, at a considerable injury to its own value, and also at considerable "expense."

Now as the opposition which, for these reasons only, the landowners and occupiers made to the proposed London and Birmingham Railway last session, was the cause of the bill being thrown out by the Lords' Committee *; while, in addition to thus losing them their bill, this opposition of the landowners and occupiers also cost that company 50,000*l.* in parliamentary expenses†, it may behove you to calculate seriously the consequences of similar opposition; parliamentary expenses being almost the same, whether a bill is for a railway of 100 miles, or of only one mile in length.

But this *surface* expense of the road may still form its least expense. Among the evidence before the Lord's Committee on the Liverpool and Manchester Railway, stands the following item: "Maintainance of way 6,599*l.* 12*s.* 6*d.*" This being for the six months ending on the 31st December last, it appears that the expense of keeping that railway in condition, notwithstanding that it has been opened only two years, was at the rate of 438*l.* per mile, per annum, for the last half of *last* year; an amount, which, on your proposed line, would pay 5 per cent. on above 20,000*l.*

In the last *general* return made to Parliament, it was stated that the average expense of

* The decision of the Committee reported to the House of Lords, was, that "It does not appear to the Committee that the promoters of the bill have made out such a case as would warrant the forcing of the proposed railway through the lands and property of so great a proportion of dissentient landowners and proprietors."

† "The London and Birmingham Railway, in seeking an act, spent 50,000*l.*: and, as they did not get the act, that sum was lost to them."

Mr. Hodgson's speech, at the Liverpool and Birmingham Railway meeting, held at Liverpool on the 21st of September last.

keeping the whole of the turnpike roads of England in repair, was 63*l.* 13*s.* 0*d.*, per mile per annum. Therefore, it appears, that the expense of keeping the Liverpool and Manchester Railway in repair, is seven times as great as that of the average expense of repairing the turnpike roads of England.

For the first half of the present year, these expenses seem to have increased considerably in proportion. Since, notwithstanding that the number of passengers carried between the 1st of January and the 1st of July, 1832, is less by above 82,000 than during the preceding six months (being only 174,122 instead of 256,321), the repairs of the railway cost 7331*l.* in that period, which is at the rate of 488*l.* per mile, per annum.

On this and a corresponding subject, the Foreign Quarterly Review for October, 1832, in its observations on two French publications on railways, says, speakingof the Liverpool and Manchester Railway, "The rails are not supported uniformly by laying on the surface of the road, but rest "upon stone pillars, or sleepers, as they are called, placed at distances of a yard from each other; "and as the great weights pass over them with considerable velocity, these sleepers are driven "deeper into the ground; so that the rail-road soon becomes uneven, one rail having one direction, "and the next a different one. Though these defects are not easily detected by the eye, yet "they are very sensible upon close inspection with instruments; and still more so by the carriages "that pass over them, as the wheels, on passing over a joining of two rails, receive a severe jolt, "and also a change of direction. Driven first on one side of the road, then on the other, the "carriage rocks like a ship at sea; whilst, at every swing, one wheel or the other strikes a rail "with considerable violence.

"The damage sustained by the Liverpool and Manchester Railway, from these causes, is by "no means trifling. On examining the last half yearly statement printed for the use of the "subscribers, we find that the repairs of the railway cost 7331*l.* in six months; being more than "14,000*l.* per annum.* But the evil effects of this action are by no means confined to the railway "itself, they are still more destructive to the engines that run upon it, as well as the carriages; "as the former, from their delicate mechanism, receive the shocks with unmitigated violence; by "which every bolt is shaken loose, and even the strongest parts of the machinery, are speedily "torn to pieces.

"The jolting they receive is very violent. We have stood on one of them for hours, watching "the action of the springs, and have experienced, on our own bodies, every jolt of the railway. "The effect produced is most sensibly perceived, where it is most sorely felt, in the revenue of "the company; for even at this moment, when their engines are new, and in the best order, the "expense incurred for their support and repairs, is 10,582*l.* in six months; or above 21,000*l.* per "annum, making, with the maintenance of the road, 35,000*l.* of yearly expenditure; the greater "part of which is occasioned by the imperfections we have been describing. This expense is "easily accounted for, when we consider that the company have twenty-four engines; out of "which there are seldom more than six fit for use; the others, undergoing the progress of "thorough repair."

Supposing this 10,582*l.* to be divided among the whole twenty-four locomotives which are kept to do the work, the expense of their repair is 882*l.* per engine, per annum.

* 488*l.* per mile, per annum.

But supposing it to be divided only by the number of those which *actually do the work*, this expense for repairs amounts to 352*l.* per engine, per annum.

The Edinburgh Review for October, 1832, in some measure accounts for this enormity of expense, by saying, "It is said that in the engines used on the Liverpool Railroad, new grate-bars "have been melted in a single trip; and the projector of a steam carriage has admitted that "cylindrical grate-bars, an inch in diameter, could not last more than a week, when the carriage "is in constant work."

Now as you must have two locomotives (if not more) in constant work, the money expended in their repairs, and in those of your railway—supposing them to be equal to the similar expenses of the Liverpool and Manchester Railway: and any circumstances which should render them less remain yet to be made known—this money would, provided it could be saved, pay 5 per cent. on a capital of nearly 170,000*l.*: an amount that may render a method, the repairs and current expenses of which, should be importantly less than this, not undeserving of your attention.

In addition to these reasons against a railway, it may be observed, that, supposing you were to lay down such a line of communication for the purpose of conveying passengers to the Birmingham Railway from the west end of London, it will be necessary, not merely that those passengers should be willing to be so conveyed by you, but also that they should be willing to pay, not only you for carrying them to the Birmingham Railway, but also other persons for bringing them to your railway (which will be two miles and a half from Hyde Park corner), in order that they may, thereby, be conveyed to the Birmingham Railway: that is, they must pay you for carrying them thither, over the space of two miles and a half, and other persons for bringing them two miles and a half more from Hyde Park corner, in order that you may so carry them.

Now as the Birmingham Railway crosses the Edgeware Road only two miles and a half from the bottom of Oxford Street, it admits of rather more than doubt, whether, even if you were to lay a railway down, passengers for the Birmingham Railway would take the circuitous, five-mile course, of the Kensington Road, and of your line to it, when they could get thither, both for less money, and in less time by the two and a half miles course of the Edgeware Road.

Therefore, with a view, first, to obviate this objection, and render the course by your proposed line, quicker in point of time, as well as cheaper in point of expense, than the shorter course by the Edgeware Road; and, in consequence, cause passengers to the Birmingham Railway to give your line the preference: second, in order importantly to reduce the cost of the ground required for your proposed line: third, to remove the objections of the owners and occupiers of this ground to a railway being carried through their properties; and thereby save you the expense, as well as the danger of their parliamentary opposition: fourth, to avoid the opposition of, and the great parliamentary expense you would be put to by, the Grand Junction Canal Company: fifth, to furnish you with a cheaper (in point of current expenses as well as first cost), and better method of conveyance, than either canal or railroad will admit of: and, sixth, to possess you of a source of income additional to, and exclusive of, all that either canal or railway would bring in:—for these six reasons,

I solicit the honour of your attention to a method of conveyance, which I beg leave to introduce to your notice, by the following quotations:—

First, from the pamphlet of the gentleman who has informed the world, that what all engineers have hitherto pronounced an "impossibility"—rapid conveyance on canals that is—is now proved perfectly practicable by passengers being daily carried from Johnstone to Glasgow, along the Paisley and Ardrossan Canal at rates of ten or twelve miles an hour *: and, second, from Philip's History of Inland Navigation in England.

Adverting to the aqueducts by which the Union Canal is carried over the various rivers in its course, Mr. Grahame says:—

"Each and all of these aqueduct bridges are higher than any on the Liverpool Railway.

"The Sankey viaduct bridge, which cost nearly as much as all the other railway bridges put "together, consists of nine arches of fifty feet span; and is, at the highest point, sixty feet in height. "The Avon aqueduct, on the Union Canal, consists of twelve arches, each fifty feet span; the greatest "height eighty-five feet; and the average height seventy-four feet above the valley and river."

Therefore, it appears, that to carry a wide and deep canal across rivers, is now a matter of as common occurrence, as to build a suspension bridge, or a chain pier. Yet mark how the first proposition for any thing of this kind was treated half a century ago.

Philips, in his "History of Canal Navigation," speaking of the *first* proposition of the great father of canal navigation in England to carry a canal across a river, says:—

"When the first canal ever cut in England was completed as far as Barton, where the Irwell "is navigable for large vessels, Mr. Brindsley proposed to carry it over that river, by an aqueduct "thirty-nine feet above the surface of the water in the river.

"This, however, being considered as a wild and extravagant project, he desired (in order to "justify his opinion towards his noble employer) that the opinion of another engineer might be "taken; believing that he could easily convince an intelligent person of the practicability of the "design. An engineer of eminence was accordingly called; who, being conducted to the place "where it was intended that the aqueduct should be built, ridiculed the attempt; and, when the "height and dimensions were communicated to him, he exclaimed, 'I have heard of castles in the "air, but never was shewn before, where any of them were to be erected.'

"This unfavourable verdict did not deter the duke from following the opinion of his own "engineer. The aqueduct was immediately begun; and it was carried on with such rapidity and "success, as astonished all those who, but a little before, thought it impossible; and within a "twelvemonth did the crews of the vessels navigating the Irwell see the duke's barges sailing "over their heads, in the channel, upborne by this 'castle in the air.'"

Now as the subject to which I solicit the honour of your attention, though equally practicable as the passages which I have quoted prove it to be to carry canals across rivers, will, at first sight, appear still more aerial than was this denounced "castle in the air" of the great introducer of canal navigation in England; and, as the engineers of the present day will pronounce it still more "absurd" and "impossible" than his proposition was considered to be, it behoves me to entreat, that you will vouchsafe a correspondingly increased portion of forbearance, to what I proceed to submit.

* Vide Grahames' Letter to Wood on Chapter IX. of his Practical Treatise on Railways: and his "Letter to the Traders and Canal Carriers, on the Navigations connecting Liverpool and Manchester."

Many years ago, a circumstance which it is not necessary I should state, caused me to turn my attention to the best and cheapest means of conveying our persons and goods from one place to another.

After much consideration, a method of attaining these objects suggested itself, which admitted of a rate of conveyance so enormously rapid, and unprecedently cheap, as to be, at first sight, rejected as one of those utterly impracticable conceptions, which enter the imaginations of only poets and visionaries.

Reflection, however, convincing me, that this idea was, in point of fact, no more 'absurd than steam navigation, steam conveyance on land, and gas lighting were deemed twenty years ago, I took the same course with it which Fulton took with respect to steam navigation, which Winsor took with gas lighting, and which Trevithick and Vivian took as relates to locomotive engines—that is, I proceeded to put it in practice.

For proofs of the scale *on*, and success with which I did this, I beg to refer you to the following evidences of *fact*.

The first evidence I submit, is the copy of a circular which was sent to the principal inhabitants of Brighton, by a number of gentlemen, whose incredulity had been removed by witnessing and experiencing the operation of the method of conveyance I refer to.

" Brighton, May 5, 1827.

" SIR,

" The undersigned, having witnessed the operation of Mr. Vallance's principle " for conveying persons and goods by atmospheric pressure; and believing (if what we have seen " on a scale of yards can be extended to miles*) that it may be rendered very advantageous to the " town of Brighton, beg to solicit your attendance, on Saturday the 12th May, at the Old Ship, at " three o'clock.

" T. R. KEMP.†
" PHILIP L. STOREY.
" DAVID SCOTT.‡
" THOMAS YATES, M.D.
" JOHN LAWRENCE.
" WILLIAM KING, M.D.
" JOHN LASHMAR.
" H. M. WAGNER.§
" J. S. M. ANDERSON.‖
" JOHN GLAISYER.
" ISAAC BASS."

Meetings, in consequence, took place, from the last of which emanated the following requisition to the High Constable, to convene a "Town Meeting" on the subject.

* This allusion is to the number of miles between Brighton and London: which was the *comparative* length of what they saw.

† Member for Lewes, and principal ground landlord of Brighton.

‡ Baronet and magistrate for the county.

§ Vicar. ‖ Curate.

" To the High Constable of the Town of Brighton.

" SIR,

" We, whose names are undersigned, do hereby request that you will call a " meeting of the inhabitants of the town of Brighton, for the purpose of taking into consideration " the best means of rendering the method invented by Mr. Vallance, for the conveyance of " passengers and goods by atmospheric pressure, beneficial to the town of Brighton."

[Signed by about eighty of the inhabitants.]

In consequence of this requisition, the High Constable took the usual course of convening town meetings at Brighton, by advertisements in the newspapers, and by crying, and placarding the requisition all over the place, with the following addition at the foot of it:—

" In compliance with the above request, I do hereby call a meeting, to be holden at the " Old Ship Tavern, Brighton, on Tuesday, 5th June, 1827, at eleven for twelve o'clock.

" E. H. CREASY, H. C."

A " town meeting" accordingly took place; though, prior to stating the resolutions which were then passed, I solicit your attention to the following paragraph from the Brighton Herald of the 16th September previous; for the reason, that the explanation which it gives of the method alluded to, may serve to render more evident the justness of the decision to which the said " town meeting" came.

" NEW MODE OF CONVEYANCE.

" Our readers may remember that about two years ago, we discussed, somewhat at large, " a principle of motion, by which, it was stated, we might be conveyed from one place to another " ten times as fast as we now travel; that is, one hundred miles an hour instead of ten. It is " unnecessary to say that expedition such as this, appeared so utterly beyond what was conceived " to be within the bounds of possibility, that the theory was consigned to the oblivion it seemed to " merit; and the author of it classed among those for whom, in the opinion of the world, St. Luke's " is the only fitting residence.

" General, however, as this opinion was, we have, during the past week, witnessed that which " most importantly counteracts it as relates to ourselves; and could the doubts which the world at " large entertain on the subject, have been concentered in a number of individuals, small enough " to have both seen and felt what was experienced by us, we see not how the whole world could " have avoided entertaining the opinion, that it is as certainly in our power to cause ourselves to be " conveyed from one place to another at the rate of 100 miles an hour, by combining the operation " of the necessary apparatus, as it is to cause ourselves to be conveyed at the rate of ten miles an " hour, by adapting wood and iron so as to form the combination of apparatus commonly designated " a stage coach; and that too, with a degree of safety and convenience at which stage coaches can " never arrive.

" It may be recollected that the principle, or theory alluded to, was, that by properly com- " bining the operation of steam-engines and air-pumps, such as are daily used for certain large " manufacturing processes, we might create a kind of artificial wind; which wind, if made to blow " in a previously constructed channel, would draw, or drive, a properly constructed carriage, at

" any rate not greatly exceeding what has been adverted to. Since, as in manufacturing processes
" air is daily caused to move at rates varying from 200 to nearly 700 miles an hour, a proper com
" bination of the same apparatus must certainly enable us to cause it to move at the lower rate o
" 100 miles an hour; and, as the current of a river will carry a vessel down at nearly the rate a
" which itself moves in its channel, so would this current of air carry us along with a velocit
" nearly equal to its own.

" This, in brief, is the theory. What we have witnessed of the practice is as follows. It bein
" impossible to give motion to the whole atmosphere, as nature does when she causes a wind, w
" were first shown into a construction which formed a channel, within which the motion of ai
" could be so directed as to cause it to blow full against any object placed inside such channel.

" This channel (which is, in fact, a very large tunnel), did not, in this instance, connect an
" two distant towns: it being of a length sufficient only to illustrate the principle; but it was sel
" evident that it (or another) might be extended to any length required. On the bottom of thi
" channel (or tunnel) was a railway, on which ran a carriage. This carriage had a circular end
" composed of thin boards. This circular end was as large as the tunnel, excepting about an inc
" all round, and was fixed to the carriage, so as to stand across the tunnel; as the sail of a shi
" stands across the line of her length. Consequently, if motion were given to the air within th
" tunnel, it would press, or blow, full against this end of the carriage, and tend to push the carriag
" forward; as the sails of a vessel going right before the wind are pressed against by the atmo-
" sphere at large. Each end of this tunnel was so connected to large air-pumps, that air could be
" drawn from one end of it, while the atmosphere was at the same time permitted to enter freely at
" the other.

" After examining the construction of the apparatus sufficiently to give us to understand as
" above, we got into the carriage; and, on the air-pumps being set in motion, we were moved
" along the railway from one end of the tunnel to the other. When we arrived there the motion of
" the carriage was reversed, and we were moved back again.

" We continued riding in this way, until we became so convinced that the invisible and intan-
" gible medium we breathe, might be rendered a safe and most expeditious means of getting from
" one place to another, as to be tired of riding.

" Further investigation gave us to perceive that the carriage might be stopped, and its motion
" reversed at pleasure; that so trivial was the degree of exhaustion (or vacuum) necessary to enable
" the atmosphere to drive the carriage forward, as the air-pumps drew the air from before it, that
" though we were exposed to this "vacuum" (as it is called) at every other turn of the carriage,
" yet did we experience no inconvenience from it. In fact, our feelings gave us no intimation on
" the subject, and we were wholly ignorant of it until it was pointed out to us. We were satisfied
" that persons or goods might be taken up, or set down, in any place through which the tunnel ran,
" or whose trade or population were at all important. And, as we were also convinced that it
" would be impossible to be overturned, it was out of our power to resist the belief that we had
" witnessed the operation of a principle by which we may be conveyed more safely, more cheaply,
" and many times more expeditiously, than we now travel.

" We cannot expect to carry to the minds of those who have not witnessed the operation of this
" principle, the conviction felt by us who have. But of this we are satisfied, that whoever sees it,

" will, with us, be satisfied, that we can render the principle practically effective, whenever we " choose to be at the expense of doing so.

" It stands now, exactly as the steam-engine stood, when Watt had completed the first one he " made: that is, certain in its effect, provided we will be at the charge of combining the necessary " apparatus. We have steam-engines and air-pumps amply large enough for the purpose. So far " from there being any insuperable difficulty in the construction of the tunnel, there are parties " ready to contract for, and guarantee the execution of it, as relates to being air-tight; and, although " we should begin by going only at the rate of ten, fifteen, or twenty miles an hour, yet have we no " doubt that, in the time necessary to instruct us how to manage the carriage under higher velo- " cities (as sailors get the "trim" of a new ship), we should be able to go several (and we see not " why *ten*) times faster than we now travel. The chief, if not the only, difficulty to surmount in " this, as in most scientific improvements in their origin, is public incredulity. This difficulty was " felt and experienced, at the outset, in respect to the construction of steam-engines; in cutting " canals; in laying down rail-roads; in rendering steam-engines locomotive on them; and superior " to the tempest and the wave, at sea.

" But as the same spirit of perseverance which enabled us to overcome these past difficulties, " will cause us to triumph over those before us with reference to this principle of motion, we are " satisfied, that it is necessary only to go on, and prosper."—*Brighton Herald, 16th September*, 1826.

This quotation from the Brighton Herald serving to convey an idea of the method of operation, I may return to the "Town Meeting": with reference to which the Brighton Gazette of the 7th June, 1827, states:—

" A town meeting, which we never saw surpassed in respectability, and seldom more nume- " rous, was held at the Old Ship Assembly Rooms, on Tuesday last, at the requisition of nearly " eighty of our most respectable inhabitants, for the purpose of taking into consideration the best " means of rendering the method invented by Mr. Vallance, for the conveyance of passengers and " goods by atmospheric pressure, beneficial to the town of Brighton. The High Constable was in " the chair."

The *course* of the business not being important, I beg to refer you to the columns of the Brighton Gazette for it, and state only the *result;* which will be found *officially* advertised in all the Brighton papers of that week, to the following effect:—

" TOWN OF BRIGHTON.

" At a numerous and highly respectable Meeting of the Inhabitants and Visitors of the Town of Brighton, held at the Old Ship Tavern, on Tuesday, the 5th day of June, 1827, for the purpose of taking into consideration the best means of rendering the method invented by Mr. Vallance for the conveyance of passengers and goods by atmospheric pressure, beneficial to the Town of Brighton:

" The High Constable in the chair.

" A Committee having been appointed at a former General Meeting of the Inhabitants, to investigate the merits of the measure now under consideration, and their Report having been read to this Meeting, expressing a decided approbation of the undertaking—

" Resolved, unanimously, that the Report be sanctioned and adopted by this Meeting.

" Resolved, that in the opinion of this Meeting the method of transmission proposed by M Vallance would be productive of the most important advantages to the Town of Brighton; and th the application of it, either as it relates to the transit of goods from Shoreham Harbour, or to t conveyance of passengers between Brighton and the Metropolis, is entitled to the most cordi support of the Town.

" Resolved, that the thanks of this Meeting be given to Mr. Vallance for bringing his importa invention before the Inhabitants of the Town.

" Resolved, that the proceedings of this day be advertised in the Brighton papers.

" E. H. CREASY, Chairman.

" Resolved, that the thanks of this Meeting be given to the Chairman for his impartial condu in the Chair."

" Report of the Committee appointed at a Meeting of Inhabitants of Brighton, held at the Ship, on Saturday, May 19, 1827:

" In pursuance of a Resolution passed at a Meeting held here, on Saturday, the 12th inst your Committee have inspected Mr. Vallance's apparatus for the conveyance of passengers goods by atmospheric pressure; and can bear testimony to the success of it; having been peatedly conveyed through the cylinder* laid down by that gentleman in Devonshire Place.

" Your Committee are of opinion, that, in the event of such a method of conveyance be established from one town to another where much traffic exists, the advantages would be incal lable, both as regards the ready transit, and saving of time and expense to the traveller merchant, as compared with the ordinary mode of conveyance. Your Committee are informed 75,000 tons of materials are annually imported into Brighton coastways, the greater part of w is landed at Shoreham, and from thence brought into Brighton, at a land carriage varying from to 8*s.* 4*d.* per ton: and your Committee having been assured by Mr. Vallance, that by his ciple of conveyance, the carriage of all goods from Shoreham might be reduced to a sum exceeding 3*s.* per ton, and yet a net annual profit of ten per cent. be returned on the sum expen are of opinion that if such a communication were established between Brighton and Shoreha would materially benefit the inhabitants of both towns; and your Committee feel confident it w receive the most cordial and general support.

" Your Committee beg further to report, that the opinions of some of the highest scien authorities upon the principle of Mr. Vallance's proposition, have been submitted to them; they have the satisfaction to state, that these authorities concur in the practicability of the me to the fullest extent; and the illustration of it which your Committee have examined, appears on a scale of sufficient magnitude to demonstrate the truth of such opinions. Should it, there be adopted between the town of Brighton and London, it is impossible to calculate the impo and beneficial changes to which it may lead.

* This word "cylinder" means the tunnel.

combine the operation of the largest pneumatic machinery in the world; the air pumps being capable of exhausting above 50,000 cubic feet* of air in a minute; and of conveying 100 tons weight over a space equal to the distance between Manchester and Liverpool, in three hours;—while the tunnel is, in point of calibre and strength, equal to the conveyance of the whole 1000 tons of goods daily passing between those places, at one time.

"Your Petitioner humbly begs leave further to represent, that the information he hath obtained during five years which he hath devoted to investigations relative to the practicability, cost, and advantages, of putting this method of conveyance into operation between our principal manufacturing towns, the outports, and the metropolis, will enable him to prove that it may be done of cast iron, for an expense which would not exceed what canals cost; while he can also prove, that in addition to combining the trade of the turnpike road with that of the canal, it would admit of goods being carried for less than half what they can be carried for on canals; and passengers in less than half the time, very much less than half the expense, and far more safely with reference to security from personal danger, than can be done on turnpike roads or railways; it being alike impossible to be overturned, to be driven against any thing, or to break down."

The last evidence I adduce, is that of a Major of Engineers in the Russian service; whom the late Emperor Alexander, after he visited England, sent over to inspect and report upon our canals and railroads. This officer was directed by the Russian Ambassador to visit Brighton, expressly to inspect my plan; with reference to which he addressed to his government a report, of which he favoured me with the following copy:—

## REPORT TO THE RUSSIAN GOVERNMENT.

"To His Royal Highness Prince Alexander, Duke of Wirtemburg, Chief of the Corps of Engineers for the Inland Communications of Russia, General of Cavalry, &c. &c.

"Your Royal Highness having commanded me to report upon all the inventions of importance that have been brought forward in England of late years, whether such were, or were not named in the instructions I had the honour to receive from your Royal Highness in St. Petersburgh in June 1824, I beg leave most humbly to submit the following particulars, relative to a proposed mode of conveyance; differing from every existing system, as much as it will surpass them in point of expedition and ultimate economy.

"In March, 1825, I was informed that a Mr. Vallance had invented a method of conveyance, by which goods might be forwarded from place to place ten times faster than can now be done; or equal to 100 miles per hour. The apparent absurdity of the proposition, and the undefined explanation then given, induced me to consider the scheme as one of the nefarious and stock-jobbing bubbles of the day; consequently I took no measures to become correctly informed on the subject; particularly as I was about leaving London for an extensive journey in the interior. Recent circumstances have, however, caused me to entertain so different an opinion to that which I then held on the subject, that I can now confidently submit to your Royal Highness an account of a method of conveyance, which will, in my humble opinion, within a few years, operate a change in the condition

* That is, between three and four hundred thousand gallons.

of the whole civilized world; and which would be productive of the most important benefits to the Russian Empire.

"The theory of this method is stated in the Treatise marked with the letter A. The practice, I have experienced personally: having been conveyed over a space sufficient to demonstrate the practicability of the principle; and although that space was not sufficient to admit of any such velocity being attained as is adverted to in the Treatise, yet there is sufficient evidence of the velocity with which air may be made to move, to satisfy any one, that on a line of proper length, the only limit to the rate at which persons or goods may be conveyed, will be that at which wheels will revolve. I will, however, first advert to the general object of the Treatise, and then comment on those parts of it which I conceive to require further illustration.

"Your Royal Highness will perceive, upon a perusal of the treatise, that the general object of the author is to prove,

"1. That it is practicable to render air a means by which we may cause a peculiar sort of wheel carriage to convey both passengers and goods ten times faster than horses can draw any vehicle now in use.

"2. That this may be done with perfect safety and convenience.

"3. That we may, at one and the same time, move a weight exceeding that of 100,000 infantry or 10,000 cavalry; and, consequently, that a whole army may, in an hour, be transported over a space of 100 miles.

"4. That this method of transmission may be put in practice, for an expense per mile, far less than what several canals have cost, as will be apparent from the amounts of the several inland navigations of the United Kingdom, stated in my Report of January last.

"5. That the expense of transport by it will be so many times less than by any present method, that military as well as commercial benefits will result from it of the most important nature; and

"6. That the stoppages, inconveniences, and delays, which would otherwise arise from those who have charge of the exhausting apparatus at each end of the line of transit, setting it in operation at an improper time, may be prevented by the new mode of telegraphic communication described in the last section of the Treatise, which, being equally efficient during the most foggy weather and darkness, as in day light and clear weather, will admit of instantaneous communication between those who direct the operations at each end; so that any thing which it may be necessary should be known at one end, may be instantaneously communicated from the other, independent of the method of conveyance itself; an arrangement, without which, the operation of the principle would ever be attended with doubt, delay, and danger.

"The vast importance which a method of transmission, combining the advantages of tenfold expedition and cheapness, must be, to an empire so extensive as that of Russia, I will not presume to point out to your Royal Highness, but pass to those particulars which appear to me to require further elucidation than the author's object allowed of his giving.

"The first thing is, the velocity at which the cause of motion, in this method of transmission, viz. the air, would move us, provided we could construct wheel carriages to go so fast. This velocity would, if raised to its maximum, be between 900 and 1000 miles an hour. But as saving nine-tenths the time now wasted in travelling post, would render the saving of portions of the remaining tenth, very unimportant, it will be unnecessary to trouble your Royal Highness with

proof that it might be possible to do so, in perhaps a large proportion; and I therefore pass to the adduction of evidence, which shows that *it is certainly in our power to save nine-tenths.*

"From the examination I have given to the construction, and what I have experienced as to the effect of the cylinder, or large tube, in which I was conveyed, according to this principle of transmission, I am convinced that exhaustion, to a degree which should give fifteen inches of mercury, may be effected—that is, half a vacuum; and as this would give an initial velocity of between 200 and 300 miles an hour, there is no reason to doubt but that a rate of motion equal to 100 miles an hour may be attained, provided wheels can revolve so fast without igniting. The operations of nature frequently impart to air a velocity of above 100 miles an hour; and in the process of fusing iron, it is artificially caused to move at rates varying from 200 to nearly 700 miles an hour. At the lower rate of 100 miles an hour, it must therefore be fully practicable to make it move.

"The second thing I advert to, is, the quantity in which air may be exhausted, or taken out of a cylinder, or line of large pipe, such as is adverted to. The blast cylinders used instead of bellows, for fusing iron, are all air pumps, and it is requisite only to arrange the valves properly, to render them condensing or exhausting pumps at pleasure. Many of these pumps are large enough to exhaust 10,000 cubic feet of air per minute. Assuming the area of the cylinder to be 100 square feet*, and the velocity at which we are to be conveyed to be 100 miles an hour, the combined operation of eighty-eight of these pumps would be required. But the one referred to in page 18, will take out 22,000 cubic feet per minute; therefore, only forty such pumps as that would be required to exhaust air from the cylinder at the rate of 100 miles an hour—a number, the operation of which there will be no difficulty in combining.

"The pressure requisite to cause air to move at the rate of 100 miles an hour, appears, by all experiments that have been made on the subject, to be less than half a pound per square inch. Calculating from this datum the power requisite to move a column of air equal to the area of the cylinder, at the rate of 100 miles an hour, would be that of 1900 horses.†

"A steam engine of fifty horses' power would, therefore, be required to each air pump, to cause the air to move at the rate of 100 miles an hour, independent both of the load to be moved, and of the friction of the air against the inside of the cylinder. With reference to the first of these—the load to be moved—it is to be observed, that, owing to the principle combining the operation of by far the best railway I have ever seen, or, indeed, can conceive, with carriage wheels six times as high as those used on the patent single line railway, friction is diminished to a degree which will admit of the same power moving a considerably greater weight than on that railway. It will, therefore, be quite safe to calculate only on the same effect being produced; and, according to this the extra power requisite to move 100 tons at the rate of 100 miles an hour, would be only 200 horses. With reference to the friction of the air against the inside of the cylinder, as referred to at pages 68 to 74, several times the power will be required; so that, were there no other means of power and exhaustion than steam engines and air pumps, objection might arise in point of expense. But, by what is stated at pages 50 and 51, it appears that neither air pumps nor steam engines

* That is, 11.3 feet in diameter.

† In the best of the large stationary engines now made, a bushel of coal will do the work of 44 horses for an hour. Therefore to make a current of air which should be capable of conveying 10,000 tons 100 miles in an hour, would require 45 bushels of coal; which is not twice so much as some steam vessels burn in the same time.

would be indispensably necessary; and although Mr. Vallance does not at present deem it prudent to give full explanation on this particular, he informs me, that whenever it may be requisite, he is prepared to prove that every purpose of exhaustion may be effected without other apparatus than what he can construct out of rough hewn trunks of trees; so that the question may be considered free from any objections which the necessity for costly machinery would give rise to in Russia.

"Thirdly, that a vehicle capable of carrying both passengers and goods, can be so adapted to the inside of the cylinder as to be moved in it by the air when operated upon by the air pump, I can vouch, from having seen and experienced it; and as the rate at which this vehicle moves, is exactly commensurate with that at which the pumps exhaust air from the cylinder, it follows, that, at whatever rate air can be pumped out of the cylinder, the vehicle will be carried forward, provided that velocity does not exceed the rate at which wheels can revolve on their axes without ignition: with reference to which, it is to be observed,

"Fourthly, that the number of revolutions made by a carriage wheel depends on the size of that wheel, as well as on the motion of the vehicle. The fore wheels of the coaches which travel with the greatest expedition, revolve, on an average, about 100 times in a minute. One of the peculiar advantages of the method Mr. Vallance proposes, is, that it admits of the wheels of the vehicles which move in the cylinder being several times larger than the wheels of carriages which run on roads; owing to their being always kept in an exactly perpendicular position, and consequently free from the strain thrown on the spokes of a common carriage wheel, by the deflections from the perpendicular, which the nature of and obstructions upon roads continually occasion. Owing to this, the wheels of the vehicles which move in the proposed cylinder may be from ten to twelve feet in diameter; or nearly four times as large as the fore wheels of a coach. The same number of revolutions, therefore, which the fore wheel of a coach makes in an hour, would move the vehicle in the cylinder forty miles; and twice and a half that number of revolutions would give 100 miles an hour. Now if a common coach wheel which moves under the disadvantages of being constantly exposed to all the clogging and impediments arising from the dust and dirt of the road, can revolve for hours together at the rate of 100 times a minute, without being greased, excepting at the end of its journey of perhaps one hundred miles, it may fairly be presumed, that a wheel which would be not only free from all dust and dirt, but also moving in a reservoir of oil would revolve 250 times a minute without heating, even had we no such evidence as that referred to in page 36. But when that is taken into the consideration, all anxiety with reference to the effect a velocity of 100 miles an hour would have on the axes of the wheels, may be dismissed.

"Fifthly, nor is it necessary that any anxiety should be entertained, as to the effect such a velocity would have on respiration; for in addition to what is urged on this matter at pages 28, 29, and 35, I have to state that, though I was purposely exposed to the 'vacuum' as it is termed, many times during my examination of, and riding in the cylinder, yet I did not experience the least inconvenience from it. Indeed, I should not have been aware of it, had my attention not been directed to it; the degree of exhaustion necessary to move a carriage, not being much more than the ten-thousandth part of a vacuum: a diminution of density, which would not lower the barometer so much as the two-hundredth part of an inch.

"Sixthly, a degree of exhaustion, or vacuum, which is not sufficient visibly to affect the barometer, being enough to move the carriage with persons in it, so as for them to experience the

effect, and fully comprehend the operation of the principle, it becomes evident that the idea at first entertained of a perfect vacuum being indispensable, is most erroneous; and the objections which at first present themselves to us, relative to the difficulty of constructing the cylinder—of making the joints air tight, and of so adapting the ends of the vehicle to the cylinder, as should prevent the passage of any important quantity of air, without occasioning great friction, are all seen to exist only in imagination. In the cylinder which Mr. Vallance has in operation at Brighton, there is a space of above an inch in width, purposely left all round between the cylinder and the end of the carriage which forms the piston, against which the air presses to drive the carriage along; yet does not the air which rushes through this crevice (though it is in the whole equal to an aperture of two square feet), prevent the operation of the principle: its sole effect being a loss of a proportion of the power employed to drive the air pumps; a loss which Mr. Vallance intentionally submits to, for the sake of proving that a very large portion of air may rush by the piston end of the carriage, without preventing the effect of the principle.—Vide pages 30 and 31.

" Seventhly, nor will the degree to which it may be necessary to exhaust, or, as it may in other words be termed, the degree of 'vacuum' required, to move even a very great weight, interpose any insuperable difficulty. In the cylinder at Brighton, a party, consisting of his Grace the Duke of Bedford, the Earl of Lauderdale, Lord Holland, Lord W. Russell, Lady W. Russell, and another lady and gentleman, were all at the same time experiencing the operation of the principle, on the day I was last at Brighton, with a degree of exhaustion not exceeding two drachms per square inch; a proportion of vacuum which would lower the barometer about one-hundredth of an inch. Practice therefore proves, as well as the arguments in pages 47 and 48, that a very trivial degree of exhaustion will be sufficient to move a considerable load; and as it will be perfectly practicable to exhaust to a degree, that should render a barometer exposed to the vacuum inside the cylinder, several, if not many inches lower than one would stand exposed to the atmosphere, I do not think the amount stated in page 37 more than it may be possible to move at one time. And with reference to weights of 50 or 100 tons, such as locomotive engines draw at once, there will certainly be no difficulty at all, let the velocity they are moved at be what it may.

" Eighthly, under the trivial degree of exhaustion which will thus, generally speaking, be necessary, your Royal Highness will perceive, that rendering the cylinder sufficiently air-tight for the purpose, will be far less difficult than it is at first supposed. Indeed, I see so many different ways of doing it, that I am satisfied it would not, in practice, prove more difficult, nor indeed so difficult, as causing some canals I have seen, to retain the water let into them.—Vide p. 45.

" Ninthly, nor will there be any difficulty in regulating the motion of, and stopping the vehicle. The shortest way of rendering this evident to your Royal Highness, will be to suppose the end of the carriage which, when in motion, stands across the cylinder, at a right angle with its course, to be capable of turning on a pivot; so that it may be moved one quarter of a circle, and placed in a line with the course of the cylinder: or edge to wind, like a sail when it shivers. The consequence of this would be, that as the air would pass by without pressing against it, the power which moved the carriage forward would be taken off; and as the wheel could at the same time be dragged by a friction lever, while other levers caused friction against the side of the cylinder, the progress of the carriage could be commanded and stopped at pleasure. This method of removing the effect of the pressure of the air against the carriage, not being that which would be made use of in practice, my

reason for adverting to it, is solely to enable your Royal Highness to perceive, that a very simple arrangement will admit of its being done. For the same reason, I only state, that to the axis of each carriage, would be connected clock work, which would shew the person who has charge of the carriage how far he has gone, and where he is, to a yard; so that there will be no uncertainty as to when and where to prepare for stopping, by gradually diminishing the motion of the carriage. There will be every facility for perfect vision, as at each end of every carriage will be fixed a portable gas light.

"Tenthly, this principle possesses an advantage over common roads, as well as rail-roads and canals, which will, under all circumstances, be generally, and, in some cases, highly important. This advantage is, that the cause of motion (the atmospheric pressure) will act vertically as well as horizontally; and that in consequence of it, the filling up of hollows, and also deep cutting, as for canals and rail-roads, is unnecessary. Not that it would be advisable to select hilly ground; though perfectly possible to go over any, the most abrupt rises, even were they nearly perpendicular. But that any rise or fall over which a carriage road can be cut, would be quite level enough for the operation of the principle.

"Eleventhly, I now mention the expense per mile, which I think will not, in Russia, exceed 10,000*l*. The calculations on which this opinion is founded, I do not here submit to your Royal Highness; but at such time as may be necessary they will be ready for transmission.

"Twelfthly, the expense of transit, or carriage, by this principle. Assuming that the combined effect of the improved railway in the cylinder, and the six-fold diameter of the wheels, should not render any given power capable of moving more than on the single-line railway (vide my Report of August, 1825), one horse would move twenty tons; but independent of the effect which the wheels, being six times larger, would have in diminishing friction, the expense of transmission would be diminished many times, from the following circumstances:—On the single-line railway, the power employed is that of horses; and, considering the construction of that railway, and the height the rail must be in some situations above the ground, I do not conceive that locomotive engines can be ever used upon it. Horse-power is twenty-four times as dear as elementary power, employed in the way the Treatise points out. Assuming, therefore, that the friction of the rarified air against the inside of the cylinder, as stated at pages 68 and 74, should increase the power required ten times, still would the expense of carriage be less than by the single line railway, while we should attain the important advantage of being able to transmit 10,000 tons, at any rate between what railways now transmit at, and 100 miles per hour, for an expense which, as relates to power, would be only the twenty-fifth part of a farthing per ton per mile.

"But even were the friction of the rarefied air against the inside of the cylinder to increase the power required ten times, as I have supposed, it is not imperative that the expense of transmission must be increased in a similar degree. Owing to its being well-known and universally received, steam is the first mover, or power, Mr. Vallance has referred to. The researches of men of science in England have, however, been for some years directed to means of rendering the gases first movers, instead of steam, under the hope of obtaining an agent, which should serve as a mechanical first mover, without fuel. From the year 1820, the attention of Mr. Vallance has been directed to this subject, with a view of rendering the method of conveyance the Treatise refers to perfect, in the particular of cheapness of transmission; and about two years ago he obtained a patent for a

first mover, which will give ten times the power of steam, without any expense for fuel; the principle of which is stated in the Tract, marked letter B, which I have obtained from him, for the perusal of your Royal Highness. The power therein referred to, proposed to be used instead of steam, would so greatly reduce the expense of transmission, that the cost of power would be ten times less than by the single line rail-road.

"It will also be equally superior in point of safety and security from accidents, as it is in point of economy and expedition; it being, as stated in page 81, absolutely impossible to be overturned.

"Thus combining expedition exceeding that of posting, with economy equal to that of canal transmission, it must appear that this principle is most importantly advantageous to an empire so vast in its extent as that of Russia, and, consequently, fully authorizes me most strongly to recommend that the Government should immediately contract with Mr. Vallance, to send a practical illustration of the principle, such as he has in operation at Brighton, which, being capable of carrying your Royal Highness, the Members of the Council, and Generals of the Arrondissements, over a space sufficient to demonstrate the practicability of the proposition, will place within command a reply to all objections from ignorant or interested persons.

"It has been deemed essentially important to the welfare of Russia to promote internal communication by canals, and immense sums have been expended in cutting them; but owing to the long duration of winter, they are useless during half the year; and so slow is the rate of transmission by them, that, even when in full operation, they can hardly serve to convey goods from one part of the empire to the other, before winter locks them up again. Railways also, owing to the period the snow lays on the ground, and the continual drifting of it which takes place, would be available scarcely more than half the year. But the principle here adverted to, being liable to interruption from neither frost nor snow, and equally effective by night as by day, offers a means of rendering the extremities of the empire contiguous to each other; and will do this at a much less charge than can ever be done by canals, or any other mode of conveyance.

"The vast importance of this principle to Russia, both in a military and commercial point of view, it is unnecessary for me to state to your Royal Highness; but I consider the manifold advantages it presents sufficiently demonstrated, to prompt me to recommend its speedy adoption from St. Petersburgh to Tsarsko-selo, the river Volga, Moscow, and the Black Sea.

"WILLIAM COULING, K. V. &c.

"London, Dec. 21, 1826."

With these evidences that I do not presume to request your attention relative to a mere theory, I trust I may be permitted to hope, that the following observations relative to effecting a communication between your canal at Kensington and the point of termination you propose, may be deemed not wholly undeserving attention.

Were you to purchase land for either a canal or a railway, the width required would not be less than sixty or seventy feet, while in some parts it would be much more on account of the cuttings and embankments.*

* The proposed London and Birmingham Railway is to be sixty feet wide in the narrowest places; notwithstanding that it is to have only the same number of lines of rails which you must have; while, in some parts, it will be between two and three hundred feet wide. The average width of its *whole* line will be 92 feet.

Supposing the method which I submit to you were to be adopted, a width of only eight feet would be necessary, even were the tunnel to be carried, as a canal or railway must be, along the surface of the ground; so that my proposition has, to recommend it, this first feature, that only one-eighth of the ground would be wanted that must be required for either a canal or railway; while this recommendation would be attended with the additional advantage, that, instead of the tunnel rendering the lands through which it would pass, open, and liable to the depredations of the bargemen and drivers, as canals or railways do, it would, owing to communication going on *inside* the tunnel, leave them still as private, untrenched upon, and uninvaded, as a water or gas pipe would do.

In order, however, still more to obviate objections as to the course, and additionally to reduce expense as to the nature of the ground required for the line of communication which I suggest, I propose carrying the tunnel *under* ground, in lieu of upon it; while, instead of taking its course across fields and cultivated grounds—as a canal or railway must do—I propose taking it along the line of (though buried underneath) certain bye-roads and (to coin a word) uncultivatible grounds lying between your basin and the Grand Junction Canal, and the line of the London and Birmingham Railway; by doing which, I anticipate that very great expense, and still more important opposition, will be avoided; while, as the farm-roads and tracks, along and underneath which I propose to carry the tunnel, would be so importantly improved by it, as to be rendered almost equal to turnpike roads, the execution of the work would be an actual benefit, instead of an injury to the land under which it was carried.

In addition to these things, the line I propose would save five per cent. on the whole cost; owing to its being in that proportion shorter than the line pointed out on the plan for the railway which was laid before the meeting.

The course I propose is as follows. 1st. Along the road on the east of your basin, to the turnpike road; in which length I should sink it so as to go under the turnpike. 2nd. Diagonally across the turnpike to the bottom of Addison Road; up and underneath which it would be continued to the Uxbridge Road. 3rd. Under that road, and the farm yard and ground opposite Addison Road, to the Green lane which runs upwards by the side of Morland Hall; where would be the only *cultivated* ground (and that only two or three furlongs) which it might be necessary to purchase.

From this point it would go under the track to Notting Barn Farm; and from thence under that farm yard up the track to the bridge now crossing the Grand Junction Canal; where I propose obviating any opposition of the Grand Junction company, by fixing the bridge which must be thrown across to carry the tunnel, *close* to that bridge; so that there would still be, as it were, but one bridge for their barges to pass under.

From this point it might be carried under the short piece of road leading to the Harrow Road; and thence, under and across that road, up (though under) Kilburn Lane, to the line of the London and Birmingham Railway.

There being only between three and four furlongs, which are cultivatible throughout this route; and as the tunnel (being carried under them) would be no impediment to the usual operations of agriculture (unless some repair should, by chance, be necessary, while the crops were on the

ground) the expense of the ground line, would, comparatively, be not worth speaking of; instead of proving the costly matter it would be, as relates to a canal or railway.

And the foundation which the width of the "lengths" of the tunnel would give for the railway inside it, being thirty times greater than those of the bases on which the rails of the Liverpool and Manchester Railway are laid (*those* bases too, being of an extra and unusual size) the tunnel would be less likely to need repair as relates to its foundation, than the Liverpool and Manchester Railway is, by thirty times. Indeed, owing to the less weight there will be on each "length" of the tunnel, in comparison with that thrown on the railway bases, the probability of repair proving necessary will be less than this.

The stone blocks, or bases, which carry the rails of the Liverpool and Manchester Railway are two feet square. The weight of the large locomotive engines on that railway, is above ten tons; more than half of which, being thrown on two of the wheels, each block has three tons weight on it when those wheels pass over it. The pressure on every square inch of the foundations of the Liverpool and Manchester Railway, is, consequently, above four times as much as on the boilers of Boulton and Watt's steam-engines; from which result the sinkings, "drivings into the ground," and the twenty-fold more expensive repairs than were originally calculated on, alluded to in the extract from the Foreign Quarterly Review, given at page 11.

Now as the construction of the carriages which would go in the tunnel, would prevent more than three tons being thrown on a "length" of the tunnel; and as each of these "lengths" would expose a base of 120 square feet to the ground, the pressure on each square inch of the foundation of the tunnel, would not be one-thirtieth of what it is on the bases of the Manchester and Liverpool Railway; which, taken in conjunction with the superior bases exposed by the tunnel, would, perhaps, render the probability of sinking less than one hundredth. It may, therefore, be presumed that after the tunnel was once fairly set in its place, it never would be necessary to disturb the ground over it.

Neither will the height to be surmounted by your extension, prove an at all serious impediment to the effect of the principle which the tunnel will enable us to put in operation.

As the pressure of the atmosphere, acting in all directions, admits of a tunnel being effective even were it fixed vertically, all gradations of ascent, fall, necessarily, within in its range; with varieties of effect, increasing in proportion as their angles approach the horizon. In consequence of this, the height to be surmounted in the course of your extension, is merely an impediment of degree; while the following circumstance will render that degree comparatively unimportant.

Few things are better known than that a Stage Coachman, when he approaches a rise of the road, pushes his horses to a gallop; because "the swing of the coach" (as he expresses it) "carries his cattle up the hill." The principle is known to every one; while it is almost equally well known that the law of its operation, is according to the square of the velocity; so that the momentum of a coach which meets the hill with the horses pushed into a gallop that causes the rate of the vehicle to be 16 miles an hour, will (friction abstracted) rise four times as high as one that meets the hill when going at the rate of 8 miles an hour: the continuance of the operation of the power which overcame friction on the level, being (so far as relates to its counteractive effect) equivalent to an annihilation of friction.

This law is well known. Now let us see how this knowledge has been taken advantage of, by those who have had the expenditure of hundreds of thousands, placed at their discretion.

Rates of from 35 to 40 miles an hour, have been attained on the Liverpool and Manchester Railway for these four years. Supposing friction to be counteracted and neutralized, the momentum of a vehicle that was moving on a level at the rate of 36 miles an hour, would "swing" and cause it to rise up an inclined plane to the height of 43 $\frac{1}{7}$ feet perpendicular, let the angle of ascent, or rate of rise, be what it might; while, as a velocity of 20 miles an hour, would, under similar circumstances, "swing" a carriage up 13 $\frac{1}{7}$ feet perpendicular, and a velocity of 10 miles an hour, 3 $\frac{1}{7}$ feet perpendicular, it needs not, *nor ever has needed* any thing more than a proper arrangement of levels and inclined planes, to avoid *all* deep cutting, high embanking, or tunnelling, in the line of a railway, except where a precipitous rise or hollow interposed itself.

It is true that it may, with reference to the deep cuttings and high embankments of the Liverpool and Manchester Railway be replied, that at the time these works were executed, it was not known that such great velocities could be attained on railways.* But though it was not then *known* that these rates of motion could be attained, yet was it as well known as it is now, that rates of ten miles an hour could be attained by horses: while, though the first line of the railway was laid out in 1824, and the present line in 1825, it was not till October, 1828, that it became decided whether horse or elementary power should be employed: vide pages 62, 67, 68, and 69 of Mr. Treasurer Booth's "Account of the Liverpool and Manchester Railway."

And notwithstanding that instances of velocities equal to ten miles an hour having been attained by locomotive engines, were not very common at the time the line of the Liverpool and Manchester Railway was laid out, yet do the under-quoted extracts from various publications of the period prove, both that they *had* been attained, and that much higher velocities were confidently anticipated: while Mr. Treasurer Booth, at page 37 of his book, says, that "the earth work (comprising the cuttings and embankings along the whole line) was not commenced till January, 1827."†

* An idea of the amount of these cuttings and embankments may be given by the following statement. Every one remembers what our school days taught us, relative to the "Great Pyramid:" the many years it was in building: the multitudes of workmen employed: and the vast sums expended to supply those workmen with merely "garlic and onions." The excavations of the Liverpool and Manchester railway, would, if put in one lump, have formed a mass larger than that of the "Great Pyramid:" its cubical contents being only 2,983,263 yards; while the excavations for that railway amount (according to its treasurer's statement) to 3,405,000 cubic yards: or 11,386,899 cubic *feet* more than the whole mass of the "Great Pyramid."

† "A locomotive engine of ten-horses power will draw 120 tons at the rate a draught-house generally travels; or 50 tons at the rate of six miles an hour. I may here remark that the rate of travelling may be increased to surpass that of mail coaches; and that the locomotive engine will as readily convey 25 tons (including its own weight) at the rate of twelve miles an hour, as double the weight in twice the time."—Mr. Jessop's Second Report to the Committee of the Proposed Railway from Cromford to the Peak Forest Canal, at Whaley Bridge. Dated 29th November, 1824.

"An engine of four horses' power, employed by Mr. Blenkinsop, impelled a carriage, lightly loaded, at the rate of ten miles an hour; and when connected with 30 coal waggons, each weighing more than three tons, it went at about one-third of that pace."—*Observations on a General Iron Railway, by Thomas Gray.* 1825.

"They saw two locomotive engines, for drawing along these roads; but they were not at work. The boilers of these engines were eight feet long, and four feet diameter: and they usually took down fourteen waggons, carrying 53 cwt. of coals each, at about four miles an hour. The engineer said that he once took nine loaded waggons, one mile in five

Such statements being (as it were, officially) promulgated, and such opinions entertained relative to the velocities attainable by locomotive engines—: the question as to the employment of horses being, thus, an open one, not only during the survey for the second line, but also for two years and a half after the Act for the Liverpool and Manchester Railway was obtained: and it being equally well known as it is that the sun gives light, that for the gallop which coachmen push their horses to just before touching a hill, in order to give their vehicles the momentum which imparts the "swing that carries their horses up the hill", rates of 15 or 16 miles an hour could be attained—it being thus known at the time the line of the Liverpool and Manchester Railway was laid out, that average velocities of 10, and occasional velocities of 15 miles an hour could be attained: and it being unquestionable that if friction be counteracted (as it is by the continuance of the operation of the moving power) the momenta imparted by those velocities will carry any vehicle up any inclined plane to the heights of $3\frac{1}{3}$ and $7\frac{1}{2}$ feet, it was necessary only to have laid out the railway in short levels, with sharp inclined planes rising a foot or two between them, to have avoided all deep cutting or high embanking.

It is true that owing to velocities of ten miles an hour, having at that time, been only occasionally attained by locomotive engines, it might have been proper to keep these ranges of levels, and inclined planes *within* the limit prescribed by that rate. But as this limit is not within a vertical rise of 3 feet 4 inches, it would have been perfectly possible, by arranging short levels with sharp inclined planes of three feet in height between them, to have avoided the *whole* of those deep cuttings and high embankments of the Liverpool and Manchester Railway, of which the underquoted extract from Mr. Treasurer Booth's book gives such glowing descriptions.*

Admitting, however, (for the question's sake) that the "most eminent engineers" and their

minutes and a half, which is equal to eleven miles an hour."—Report of a number of gentlemen, who were deputed to inspect the rail-roads in the north of England, relative to the Liverpool and Manchester Railway. 1824.

"The Company are also fully persuaded, that by means of the same power, they will be enabled to convey passengers with perfect security, and at a speed of at least twelve miles an hour."—Report relative to the Liverpool and Birmingham Railway given in Cumming's "Illustrations of the Origin and Progress of Rail and Tram Roads, and Steam-Carriages." 1824.

"It is estimated, that on a level railway, a well-constructed locomotive engine of ten horse power will, without difficulty, convey fifty tons of goods at the rate of five miles an hour, and lighter weights at a proportioned increase of speed. A powerful engine will work goods over an elevation of one-eighth of an inch in the yard. Nor is there the least doubt but carriages for the conveyance of passengers, or light packages, may, with perfect ease and security, be propelled at the rate of twelve miles an hour."—*Cummings' Illustrations of the Origin and Progress of Railways.* 1824.

"By the locomotive engine, fifty tons of goods may be conveyed by a ten-horse-power engine, on a level-road, at the rate of six miles an hour; and lighter weights at a proportioned increase of speed. Carriages for the conveyance of passengers, at the rate of twelve or fourteen miles an hour."—Courier's preliminary remarks to the "Memorial of the Subscribers to the projected Railway between Liverpool and Manchester:" dated 1st June, 1824.

"One of the railway companies at present contemplates a speed of only eight miles an hour; but another, in its prospectus, speaks of conveying passengers at *twice* the speed of the present stage-coaches; and we look forward, pretty confidently to the attainment, in a few years, of a velocity of 20 miles an hour. Several millions sterling are already subscribed for accomplishing these great projects."—*Leeds Mercury, 24th December,* 1824.

* "The railway a little beyond Wavertree-lane is carried through a deep marle cutting, under several massive stone archways, thrown across the excavation to form the requisite communications between the roads and farms on the opposite sides of the railway. Beyond the marle cutting is the great rock excavation through Olive Mount, about half a mile to the north of the village of Wavertree. Here the traveller passes through a deep and narrow ravine, 70 feet below the surface

"assistants of undoubted talents," by whom these "Pelion-upon-Ossa-like spoil banks, towering over the adjacent land" were ordered—and of which Mr. Booth says, in addition, "this aggregate mass has been removed to various distances, from a few furlongs to between three and four miles; and no inconsiderable portion of it has been hoisted up by machinery from a depth of 30 to 50 feet" —admitting that these gentlemen should have been warranted in expending the hundreds of thousands which were paid for making these mountains between Liverpool and Manchester, by the uncertainty then prevalent as to what velocities were attainable by locomotive engines, it cannot be said that the engineers of the London and Birmingham Railway have any similar justification to plead. That line was not, I believe, laid out till 1831, while the velocities attained on the Liverpool and Manchester Railway, and the short time within which London and Birmingham could, in consequence, be brought of each other, form the main features of the prospectus: rates of from 35 to 40 miles an hour having been (then) *long* attained on the Liverpool and Manchester railway.

Yet does the "Estimate" laid before Parliament shew no less a sum than 429,286*l.* appropriated to "Excavations, Embankments, and Tunnelling," which, with "the increase in the number of arches in the Wolverton viaduct," will give an *estimated* expenditure of nearly half a million to do that, which, taking *proper* advantage of the law of motion I am adverting to, would entirely have saved; except where a hill as perpendicular as a wall, or a hollow as precipitous as a well, rendered tunnelling, deep cutting, or filling up, absolutely unavoidable.

At the time the Birmingham Railway was before Parliament last session, maps of it were

of the ground, little more space being opened out than sufficient for two trains of carriages to pass each other; and the road winding gently round towards the south-east, the prospect is bounded by the perpendicular rock on either side, with the blue vault above, relieved at intervals by a bridge high over head, connecting the opposite precipices. At night, when the natural gloom of the place is further deepened, the scene from the bridges above will readily be imagined to be novel and striking. The light of the moon illuminating about half the depth, and casting a darker shade on the area below—the general silence interrupted at intervals by a noise like distant thunder—presently a train of carriages, led on by an engine of fire and steam, with her lamps like two furnaces, throwing their light onward in dazzling signal of their approach—with the strength and speed of a war-horse the engine moves forward with its glorious cavalcade of merchandize from all countries and passengers of all nations. But the spectacle is transient as striking; in a moment the pageant is gone—the meteor is passed; the flaring of the lamps is only seen in the distance, and the observer, looking down from the battlement above, perceives that all again is still, and dark, and solitary.

"Emerging from the Olive Mount cutting, you approach the great Roby embankment, formed of the materials dug out of the excavation we have described. This embankment stretches across the valley for about two miles, varying in height from 15 to 45 feet, and in breadth at the base from 60 to 135 feet. Here the traveller finds himself affected by sensations the very reverse of what he felt a few minutes before. Mounted above the tops of the trees, he looks around him over a wide expanse of country, in the full enjoyment of the fresh breeze, from whatever quarter it may blow.

"This vast embankment strikingly exhibits how much may be accomplished when our efforts are concentrated on one grand object. There is a feeling of satisfaction by no means common-place, in thus overcoming obstacles and surmounting difficulties, in making the high places low and the rough places plain, and advancing in one straight and direct course to the end in view; while the pleasure afforded by the contemplation of this great work is further enhanced, when considered in contrast with ordinary and every-day impressions." p. 50—52.

"A few miles beyond Newton is the great Kenyon excavation, from which about 800,000 cubic yards of clay and sand have been dug out, part being carried to form the line of embankment to the east and west of the cutting; and the remainder, deposited as spoil banks, may be seen heaped up, like Pelion upon Ossa, towering over the adjacent land." p. 55.

"Beyond Chat Moss we traverse the Barton embankment, crossing the low lands for about a mile between the Moss and the Worsley Canal, over which the railway is carried by a neat stone bridge." p. 57.

issued from the office of that company, which gave the "Section of the line of railway; shewing the rises and falls."

This section is on too small a scale to shew either the height of the embankments or the depth of the cuttings: and though it has not suited my convenience to spare the time necessary for examining the section deposited in Parliament, yet as the cubic yards of cuttings and embankments amount to nearly twenty-three millions: as the map and section I have just mentioned shew ten tunnels (some of which are a mile and upwards in length): and inclined planes, in *unbroken* rises of 6, 8, 10, 11, 13, 20, and 25 miles, there can be no doubt but that *much* deep cutting and high embanking is included in it. Now though I do not mean to imply that the expense of *all* cutting and embanking could have been saved, by taking proper advantage of the power of ascending heights, which is imparted by the momenta of the velocities whereat locomotive engines now go, yet I do mean to state it as my full conviction, that had this railway been (as the second prospectus of the Liverpool and Manchester Railway, stated that line should be) "laid down and arranged with that skill and conformity with the rules of mechanical science, which will equally challenge approbation, whether considered as a national undertaking of great public utility, or as a magnificent specimen of art" the whole of the anticipated expenses of *deep* cutting and *high* embanking would have been expunged from the estimates; it being certain, that deep cuttings, high embankments, and *long* inclined planes are no more evidences of engineering skill, than winning a battle by hard fighting is of generalship: while the expense of the numerous "very small cuttings varying from 8 to 10 feet," which are spoken of in the "Minutes of Evidence taken before the Lords' Committees," might as certainly have been saved, and those rises passed over by the vehicles in consequence of their momentum, as a cricket ball will roll over a mole-hill.

But if these remarks are applicable to the Birmingham Railway—the line of which, was I believe, laid out in 1831—what must be said relative to the *now* proposed London and Bristol Railway?

For nearly twelve months the principle of avoiding level, and constructing "undulating railways" has been discussed, in consequence of Mr. Badnall having taken out a patent for, and published a work, proposing such "undulating railways": and though, owing to the fall on your line being wholly (as well as *greatly*) one way, it is not necessary to express any opinion here on a proposition, which appears to have for its object the construction of unlevel railways in *preference* to level ones, and the labour of toiling up hill for the sake of the momentum to be obtained by running down hill, yet as, in consequence of it, the effect of momentum in carrying moving bodies up ascents, has been largely and widely adverted to for the last twelve months (nearly), it must have been within the expectation of every one, that, let the gentleman who has been employed to lay out the line of the Bristol Railway be anxious as he might, to avoid any "undulating" proposition, he would be equally anxious to call in the aid of all *known* and *established* principles, to diminish the expense of the line he was required to lay down.*

Now, nothing, I believe, is more certain, than that if a vehicle be moving along a level at the rate

* In evidence that the observations which will be found in the course of this letter, relative to the effects of momentum, are not of such recent origin in my mind, as Mr. Badnall states his idea relative to this "undulating railway" to have been in his, I beg to direct attention to the testimony given by the Appendix.

of $2\frac{3}{4}$ (2.7272) miles an hour, it will, on coming to an inclined plane, and provided the operation of the power which overcame friction on the level, be continued, so as to neutralise and (as relates to counteractive effect) annihilate friction during the ascent, "swing" itself up, and rise to the height of (that is, its momentum will cause it to rise to the height of) three inches perpendicular; let the angle of ascent, or rate of rise of the plane, be what it may.

Equally certain is it, that if the velocity of the vehicle be twice $2\frac{3}{4}$ miles an hour, that is 5.4544 miles, the momentum will (under similar circumstances as to counteraction of friction) then cause the vehicle to rise up said inclined plane to four times the height to which the former velocity raised it; or to the height of one foot. And it is equally certain, that the momenta imparted by increased velocities will, under the circumstance of the friction of the vehicle being overcome, neutralised, and (as relates to counteractive effect) annihilated, by the continued operation of the moving power during the ascent, cause the vehicle to rise up any inclined plane to the perpendicular heights stated in the following table:—

| Carriages moving on levels, at the undermentioned velocities, the motions of which are changed from horizontal to ascending, by means, either of circular or angular ascents. | | | Have momenta, which (friction being counteracted and neutralised) will cause them to rise to the undermentioned heights (perpendicular) above the level where those velocities were attained: let the rate of rise or angle of ascent, be what it may. |
|---|---|---|---|
| MILES. | | MILES PER HOUR. | PERPENDICULAR. |
| $2\frac{3}{4}$ | or | 2.7272 | 3 inches. |
| $5\frac{1}{2}$ | or | 5.4544 | 1.0 foot. |
| 11 | or | 10.9088 | 4.0 feet. |
| 22 | or | 21.8176 | 16.0 do. |
| 44 | or | 43.6352 | 64.0 do. |
| 88 | or | 87.2704 | 256.0 do. |
| 176 | or | 174.5404 | 1024.0 do. |
| 352* | or | 349.0808 | 4096.0 do. |

Now, let it have been proper as it may, that the gentleman whose name appears as "Engineer" to the Bristol Railway, should (in laying out that line) have avoided encumbering the subject with the "undulating" question, there can be no doubt that it was incumbent on him to diminish expense in every way which *established* principles admitted. And as the usual railway rate is now 20 miles an hour, while that rate will give momentum enough to cause any vehicle to rise up any inclined plane to the height of $13\frac{1}{3}$ feet (perpendicular) above the level on which it was running at the rate of 20 miles an hour, it is necessary only to lay out the line of this railway in levels, and rises of 10 feet each, to avoid (very nearly, if not *quite*) all necessity for cutting, or embanking; while *deep* cutting, *high* embanking, and tunnelling, might (except in *very* peculiar cases) have been as certainly avoided, as erecting a suspension bridge will obviate the necessity for piers and arches over a river. Yet does not this gentleman appear to have any more called in the aid

* I give this latter doubling to "excite the energies" of a renowned steam-coach proprietor; who, in answer to the question, "If your steam-coach has, as you say, gone at the rate of between thirty and forty miles an hour over common roads, how fast would it run on a rail-road?" replied, "*At least* 250 miles an hour."

of this law of motion, than did those equally "*eminent* engineers" who laid out the line of the Liverpool and Manchester Railway; or those who have laid out that of the Birmingham Railway: the "Report" of the public meeting held at Bristol, on the 30th July last, stating that "although the line of country (except for about 30 miles at the Bristol end) is *very advantageous*, yet the comparative levelness of the railway will be attained by a *great deal* of deep cutting, and *several* tunnels;" while the prospectus issued from the London office of the Company states, that "the construction of a road so nearly level, in the hilly country about Bath and Bristol, will, unavoidably, be a costly work."

The length of the Birmingham Railway is 112¼ miles; that of the Bristol Railway "from 115 to 118 or 120 miles," average 117¼. The estimated expense of the cuttings, embankments, and tunnels, of the Birmingham Railway is 429,286*l.* or 3,185*l.* per mile. The same expense on the Bristol Railway is (835,300*l.*+15,000*l.*=) 850,300*l.* or 7,236*l.* per mile; that is, above twice as much: and this too, notwithstanding that the Report states that "this expensive part of the work, fortunately, lies principally in two of the most favourable materials—the chalk and the freestone;" and also notwithstanding that the estimate of the Birmingham Railway has undergone two years' scrutiny, and the most rigid investigation, by several Parliamentary Committees; while that for the Bristol Railway is the result of only a "*preliminary* survey," directed by a "Provisional Committee:" so that were it to be increased as the estimate for the Birmingham Railway has been increased, it would be *many* times as much as the similar work on that railway. Indeed, the parties themselves have made a considerable increase already: 10 per cent. being added to the above amount of 850,300 by the Bristol Committee, and 7 per cent. by the London Committee;* so that 978,494*l.* is the *whole* amount at present allowed for works, which taking proper advantage of the momentum of the vehicles would have saved.

Yet, with well-known laws of motion thus set at nought and neglected, and with expense thus unnecessarily as well as most enormously added to, are the Committee—gentlemen who were, unavoidably, as entirely dependant on the opinion of their engineers, as the Ministry of 1789 were upon that of the "Insanity Doctors," relative to the mental affliction of George III.; or as those of 1830 were on that of the physicians who attended George IV. during his long illness—under circumstances of such entire dependance on the opinion of their engineers, are the "Provisional Committee" of the Bristol Railway led into the following expressions of approbation in their Report: "*The Committee* think it but justice to say, that the zeal, the diligence, the *ability and other valuable qualities* manifested by *these* gentlemen, have given them ample reason to congratulate themselves *on their choice*"!; and "*The Committee*, in conclusion, *repeat* that they have carefully availed themselves *of the resources of skill and experience* in investigating the probable cost of the railway."†

* By heading their prospectus, "Capital, 3,000,000*l.*"

† There is *one* manifestation of "*skill* and experience"* in the manner in which the Committee have been induced to lend their sanction to statements in their Report, which merits observation. The paragraph immediately preceding the abstract of the estimate, states that "The locomotive engines will, in no part of the line, have to surmount an inclination greater than 1 in 340; and for the first 50 miles out of London, none greater than 1 in 528. This degree of approach to

* "*Confound* that word! my unfortunate pen
Had well nigh prefixed to it *i* and *n*."

Now as, were I to presume to manifest "skill, experience, ability, and other valuable qualities," *such as these*, with respect to your line, or thus to throw away, not only hundreds of thousands, but also half millions, on any other, I should be sure to experience the truth of that proverb, which says that merely looking over the hedge shall subject one man to the operations of "the *finisher* of the law," while another man may steal the horse with impunity, I must avail myself of this law of motion, which "skill, ability, experience, and other valuable qualities" so neglect and despise, to get loads up the rise which you wish to surmount, without resorting to deep cutting or high embanking.

Sixty feet of the rise to be surmounted, occurring in the last half-mile of your line, I shall have nearly two miles to acquire the necessary velocity in: and as the continuation of the action of the power which overcame friction on the level, will neutralise, and, as relates to counteractive effect, annihilate the friction of the carriages while ascending these sixty feet, I have only to cause them to attain a velocity somewhat greater than has yet been attained on railways, that is, 42½ miles an hour during the two miles, to enable them to "swing" themselves up these sixty feet, in consequence of the momentum which that velocity will impart: while, let the height of Rodway Hill (which is adverted to as so desirable to avoid, in the Report of the Provisional Committee of the Bristol Railway) be what it may, all that would be requisite to obviate the necessity for the "inclined plane and stationary engine" spoken of as unavoidable there, would be to attain the velocity due to the altitude of said hill, to enable my vehicles to surmount it from their momentum.

Nor would the ascending power imparted by the vertical operation of the pressure of the atmosphere, be much less important with respect to diminishing the expense of bridging, on the line of this Bristol Railway, than would "momentum" as relates to the expense of cutting

a level, will render the locomotive engines much more effective, and subject them to less wear and tear than they are on the Liverpool and Manchester Railway, part of which has an inclination of 1 in 98."

At page 60 of Mr. Treasurer Booth's "Account of the Liverpool and Manchester Railway," is given a "Section of the line of Railway, from Liverpool to Manchester," which states that for 5-9ths of a mile (*from* Liverpool) it is "level;" that for the next 5⅛ miles it has a fall of 1 in 1092; for the next 1½ mile, a rise of 1 in 96, &c. &c. according to the following table:—

| MILES. | |
|---|---|
| 5/9 | Level. |
| 5⅛ | Fall, 1 in 1092; or 1 foot in about 1-5th of a mile. |
| 1½ | Rise, 1 in 96; or 1 foot in 96 feet. |
| 1⅞ | Level. |
| 1½ | Fall, 1 in 96. |
| 2½ | Fall, 1 in 2640; or 1 foot in half a mile. |
| 6½ | Fall, 1 in 880; or 1 foot in 1-6th of a mile. |
| 5½ | Rise, 1 in 1200; or, 1 foot in about ¼ of a mile. |
| 4⅓ | Level. |

Now as it appears from this, that, with the exception of the mile and half which rises at the rate of 1 in 96 (up from 1-6th to 1-3rd of which their momentum carries them) the part of the Liverpool and Manchester Railway over which the locomotive engines *work*, has no rise that is *half* so sharp as the 1 in 340, nor any which is near so sharp as the 1 in 528, adverted to on the Bristol line, it surpasses my comprehension to conceive what there can possibly be to "render the locomotive engines much more effective, and subject them to less wear and tear than they are on the Liverpool and Manchester Railway"; while I am beyond measure surprised, that the confidence of gentlemen could be so misled, as to expose them to a refutation so palpable, as the statement they have thus been betrayed into admits of.

and embanking. From the map issued from the London office of that Company, it appears that that railway is to be carried five times across the Avon; twice across the Kennet and Avon Canal; three times across the Wilts and Berks Canal; and four times across the Thames. These various crossings are not for the sake of approaching places of magnitude, or commercial importance; but solely because the *principle* of railway transmission compels the level to be servilely adhered to: while, though the right line distance between London and Bristol is only 108 miles, yet is the line of railway there laid down, shewn as being 120 miles long; the 12 additional miles being added by the curves taken in thus crossing these waters for the sake of the level.

Now though I do not mean to say that it would be possible, by laying down a tunnel instead of this railway, to avoid all bridging whatsoever, yet owing to hills and rises being no impediment to the operation of this principle, the line for a tunnel might be several miles shorter than this line of the railway, and yet the whole of these bridges be saved, excepting one over the Avon; while not a quarter of the expense would be incurred for carrying a tunnel over the waters which *its* course must cross, which will be incurred in bridging the railway over those other waters that intersect its course, which are not laid down in the map shewing its line.

The estimated expense of bridging for the railway is 474,800*l.*; which, when increased by the per centages allowed by the Committees, amounts to 556,194*l.* as the whole *estimated* expense of bridging. What proportion of this amount is for bridging over waters, and what for bridging over roads, is not stated. On the Liverpool and Manchester Railway 108,565*l.* 11*s.* 9*d.* was expended on 63 bridges; of which only five were over waters: the other 58 being over roads, or to carry roads over the railway. On the Birmingham Railway the number of bridges is 300; of which only nine *are stated* to be over waters, the others being for roads. The estimated amount of them is 350,574*l.* One bridge alone (the Sankey viaduct) on the Liverpool and Manchester line, cost nearly 50,000*l.*

Now as the power of going up or down, imparted by the vertical operation of the pressure of the atmosphere, would render it wholly immaterial whether the level was preserved in the line of a tunnel; as burying it under ground, in the manner proposed at page 27, would equally do away with any occasion for the *many* hundreds of bridges, which, on the three lines I have mentioned, must be provided to carry those railways clear of roads, as it would save bridging over the roads on your line; and as a tunnel could have been carried *under* the Sankey, for almost one-tenth of the expense it cost to construct the viaduct by which the Liverpool and Manchester Railway is carried over that canal—as my principle offers facilities of this kind for obviating the necessity of bridging—I do not hesitate to say, that, on the whole three lines, and considering how much the actual, will exceed the estimated amounts, above one million sterling might be saved in the item of bridging alone, by substituting tunnels for railways; which, when added to, as it would be, by the almost equal amount that would be saved in the expense of the land, in consequence of my plan requiring a width of only ten or a dozen feet *under* ground, instead of from 60 to 300 on the surface, will admit of my saying that (in round numbers) nearly two millions might be saved by my plan, in these two items of bridging and land, on the lines of the Liverpool and Manchester, the London and Birmingham, and the London and Bristol Railways: while, if what my plan would save of the 488,286*l.* allowed for the cost of land, and of the 261,928*l.* allowed for that of the entrances to London, Bath, and Bristol, be added to the savings I have stated it would effect in

bridging, cutting, embanking, and tunnelling, I may say that it would also save nearly two millions (of the *present* estimated expense) on the Bristol Railway alone.

The ten times greater heights than I have yet specified, which may be surmounted by combining the operation of the momentum of the *air itself* with that of the vehicles, it is not necessary for me to trouble you with, owing to the shortness of your line, and the small height to be ascended: though it may be permitted me to observe, that as attaining only equal velocities to those which have been spoken of as attainable by locomotive engines and steam-coaches, will enable my vehicles, of themselves, to surmount hills of many hundred feet in height; while combining with their momentum, the momentum of the air itself (that which is *before* the vehicles; the friction whereof will be overcome, and neutralised by the operation of the exhausting apparatus) in tunnels of proper length, and loads of corresponding weight, will enable me to ascend more thousands of feet, than the momentum of the vehicles alone will carry them up hundreds, I may be able to extend Louis le Grand's exclamation, "Il n'y a plus des Pyrennées," to "il n'y a plus des montagnes sur la terre," so far as relates to their longer preventing intercourse between countries; and consequently render the whole earth level to us, in point of effect.

In reference to the force required to overcome the friction of the medium by which the moving power operated to impel the carriages, would a tunnel be also superior to a railway. From Messrs. R. Stephenson and Locke's reply to Mr. Walker's Report to the Directors of the Liverpool and Manchester Railway, it appears that the friction of the ropes by which stationary engines draw waggons up inclined planes, is one-twelfth of their weight: while, as the latter part of your line gives a sharper rise than that of the Liverpool tunnel, the weight of the rope you must use should not be less than 7lbs. per yard; the friction and gravitation of which would be 0.7323lb. per yard, or 1289lbs. per mile. The line in the plan for the railway, which was laid before your meeting, being 2½ miles long, the whole resistance of friction and gravitation upon it would be 3222 lbs.

From experiments on the friction of air in tubes, I am enabled to state that both the inertia and friction of the air against the inside of an equal length of the tunnel I propose to you to lay down would not, when said air was moved *by exhaustion*, and conveying 50 tons at the same rate at which the same quantity is drawn up the tunnel of the Liverpool and Manchester Railway (i. e. ten miles an hour), be so much as one sixteenth part of this; while it would have this important advantage, that the heavier the load was, the less would be both the inertia and friction of the air. For instance: the degree of exhaustion requisite to admit of an equal load to what is drawn up the Liverpool tunnel (i. e. 50 tons) being moved up a tunnel of the same size as that I constructed at Brighton, and rising at the same rate your's must rise (1 in 47) by the pressure of the atmosphere, would be about the 40th part of a vacuum.

But supposing ten times this load were to be raised, the degree of exhaustion must be ten times as great, or about the fourth of a vacuum. And, as the greater the exhaustion, the less the expansive power, and, consequently the less the inertia and friction of the air inside the exhausted part of the tunnel, this "rope of air" as it has, derisively, been called, possesses the important advantage of decreasing as relates to the density, inertia, and friction, which *itself* opposes, in proportion to the increase of the load drawn by it: while, as the valves I should place at every quarter, or half, or whole mile, to be opened by the carriages as they pass them, and admit air immediately behind said carriages, would prevent there being the inertia and friction of more than

a few hundred yards of air of the *natural* density behind the carriages to be overcome, the impediment which presents an insuperable obstacle in the opinion of the numbers who have condemned the proposition (because they deemed operating by exhaustion the same as operating per plenum) diminishes, in point of fact, to a far less important hindrance, than that which is occasioned by the old system of drawing loads by means of stationary engines and ropes; since, in the present instance, the inertia and friction would not be the one-hundred-and-sixtieth part of what it would be, to move an equal quantity by the stationary engine, and rope system.

And notwithstanding that the superiority which the tunnel possesses over the locomotive system is not so great at this, yet is it important.

In the instructions given to Mr. Walker by the Directors of the Liverpool and Manchester Railway (and which called from him the Report criticised by Messrs. R. Stephenson and Locke), it is stated that "the quantity of traffic for which it will be expedient to provide the power of conveyance" is about 4000 tons, from each to the other of those places, daily.

In his publication on the Liverpool and Manchester Railway, Dr. Lardner says, "In the experiments which I have detailed, it appears that a steam engine is capable of drawing 90 tons at the rate of about 20 miles an hour; and that it could transport that weight twice between Liverpool and Manchester in about three hours."* The weight of this engine alone being 8.1 tons, the whole weight of itself, and its tender, with the necessary supplies of fuel and water, will not be less than twelve tons. Therefore, the friction of the engines (and their tenders) requisite to carry these 4000 tons at the rate of 20 miles an hour, would be 4267 lbs.

The friction of one mile of air in a tunnel eight feet in diameter, when moved at the rate of 20 miles an hour by *exhaustion* being 2881bs., the friction of it in a tunnel extending from Liverpool to Manchester, will be 8640lbs.: which, though double the friction of these locomotive engines, might be far cheaper for the following reason; and independent of the circumstance, that I could lay down a tunnel capable of carrying all these 4000 tons at one and the same time, from Liverpool to Manchester, for one-fourth of what that railway has cost;† and also independent of the circumstance that the enormous expense now incurred for the repairs of the locomotives (as stated on page 11) would also be saved.

It is well known that the smaller a steam-engine is, the larger is the proportionate quantity of fuel it requires, and the greater the proportionate expense of working it; while it is equally well known that, owing to the imperative importance of lightness and efficiency over economy in locomotive engines, this disadvantage increases in a most rapid ratio with respect to them. In consequence of this, a quantity of fuel, which, in large stationary engines, such as I should use for exhausting air from the tunnel, would do a given quantity of work, would, in the best of the locomotives on the Liverpool and Manchester Railway, do only one-sixteenth as much work.

* "*Extraordinary Performance by Steam Power.*—On the occasion of a scientific gentleman lately visiting the Liverpool and Manchester Railway, some very extraordinary performances were effected. On two occasions, a load amounting to 100 tons, was drawn by one engine from Liverpool to Manchester, a distance of above 30 miles in an hour and a half; being at the average rate of 20 miles an hour. It is said no former performance effected on the rail-road has come near this result."—*Liverpool Advertiser.*—*Times, 25th June,* 1832.

† The tunnel which I constructed at Brighton, was strong enough to bear the pressure thrown on it by one-third of a vacuum. One-fourth of a vacuum would move above 4000 tons in a tunnel 8 feet in diameter, while any tunnel I might now lay down, would be ten times stronger than that I laid down at Brighton.

Therefore it results, that, notwithstanding the friction of the air in a tunnel 30 miles long would, at the rate of 20 miles an hour, be twice as much as the friction of the locomotive engines, yet, owing to the fuel consumed by the latter, to move themselves and their tenders, being sixteen times as great as large stationary engines, such as I should use, would require to do the same work, the tunnel would, supposing the whole quantity of goods were to be carried at once, be eight times the cheapest mean of conveyance, in point of current expenses only, and without reference to its first cost being only one-fourth that of the railway; and also without reference to the whole of the enormous expense now occasioned by the repairs of the locomotive engines being saved.

But this is not the only proportion in which a tunnel might be cheaper. The 13th paragraph of the Russian Engineer Officer's Report, states, that he is "convinced that exhaustion to a degree which should give a pressure of fifteen inches of mercury may be effected in the tunnel." Now, notwithstanding that much more than this may be done in an iron tunnel, yet will I calculate on this only. Fifteen inches of mercury being 7.31lbs. that pressure on the area of the tunnel, would move above twice the 4000 tons which the Directors of the Liverpool and Manchester Railway estimated would be carried from one to the other of those places every day; which, supposing that weight to be conveyed at one time, would reduce the expense (per ton of goods carried) of overcoming the friction of air moving in a tunnel from Liverpool to Manchester, at the rate of 20 miles an hour, to one-sixteenth of what the power required to overcome the friction of the locomotive engines required to draw the same weight would cost.

And though, owing to its being a received opinion that the power required to overcome the friction of fluids increases according to the square of the velocity, we are to suppose that at 40 miles an hour, the fuel required to overcome the friction of the air would be one-fourth that of the locomotive engines, while at 80 miles an hour it would be equal to that of the engines, still would a quadruple velocity be attained, by the expenditure of only an equal quantity of fuel.

The amount of the power required to overcome the friction of the locomotive engines (and their tenders) necessary to carry 4000 tons weight from Liverpool to Manchester daily, at the rate of 20 miles an hour, is, when expressed in "horse' power" equal to the power of 225 horses working for an hour and a half. In other words, these locomotives must exert power to this amount, beyond what is required to draw the 4000 tons weight.

The power required to overcome the friction of air, which was moving (by exhaustion) at the rate of 20 miles an hour, in a tunnel of eight feet diameter, extending from Liverpool to Manchester, would be equal to that of 456 horses: which, though double the preceding, would yet be eight times cheaper, owing to large stationary engines, such as I should use, requiring only one-sixteenth part of the fuel required by locomotives to do equal work.

At 40 miles an hour (supposing locomotives could go so fast) the number of horses' power required to overcome the friction of the air in the tunnel would (according to the received opinion of that friction increasing to the square of the velocity) be 3650: which, though sixteen times greater than that of the locomotive engines and their tenders, yet, in consequence of this power being exerted only for three-quarters of an hour, instead of an hour and a half, and of fuel doing sixteen times as much work in large stationary engines as in locomotives, would be only half so expensive as the locomotives and their tenders would prove.

At 80 miles an hour (which is twice as fast as locomotives can go) the power required

to overcome the friction of the air in the tunnel, would (on the calculation that it increases according to the square of the velocity) be equal to that of 29,196 horses; which is nearly 130 times as much as the locomotive engines would require: though, owing to this power operating only 22½ minutes, instead of an hour and a half, and to fuel in large stationary engines doing sixteen times as much work as in locomotives, the expense would be only twice as great as in the locomotives, exclusive of the whole of the most enormous expense now incurred, by the repairs of the locomotives being saved (which would, alone, more than make up the difference) and also exclusive of the tunnel costing only one quarter of what the railway has cost, and of the rate of conveyance being four times as fast.

But it is not with respect to a tunnel only, that the resistance of the air opposes an impediment: this resistance being found so serious an obstacle to the progress of the locomotive engines and their loads, that in all trials of, or experiments with them, the state and direction of the wind is noted and allowed for. In the "Account of the Liverpool and Manchester Railway," published by the Treasurer of that Company (H. Booth, Esq.), he says: "Moreover, at great velocities, the resistance of the air must not be left out of the calculation. At ten miles per hour, it has been found by experiment, that the resistance of the atmosphere is about half a pound weight on a square foot of flat surface; at fifteen miles, the resistance is 1lb. per square foot; and at twenty miles, about 2lbs. per square foot: the increased resistance being, nearly, as the squares of the velocities."*

The surface opposed to the air by a steam-coach, the engines of which its proprietor told me were equal to ten horses power, I found to be 30 square feet. That, opposed by another, the engines of which were said to be equal to twenty horses power, I found to be above 50 square feet: while, when carrying four outsides on the front of the roof, this coach exposed nearly 70 square feet to the action of the air. The surface opposed to the air by the large locomotive engines now used on the Liverpool and Manchester Railway, I understand (when chimney, axle-tree, wheels, and every thing that cuts the air, is taken into account) to be about 40 feet square. Supposing it to be so, at 20 miles an hour, the air will oppose resistance equal to 80lbs. to the progress of the engine; which resistance having to be overcome at the rate of 1760 feet per minute, is equal to 4½ horses power. At 40 miles an hour, this resistance would be 320lbs.; which resistance having to be overcome at the rate of 3526 feet per minute, would be equal to 34 horses power. At 80 miles an hour, the resistance of the air would be 1280lbs.; which resistance, having to be overcome at the rate of 7,040 feet per minute, would be equal to 270 horses power; while at 100, and 120 miles an hour, the power required would be, respectively, that of 528 and 912 horses.

Now, as the force required at 80 miles an hour, is a *few* times more than the whole power of those engines, and as Dr. Hutton found that giving the moving body the form of a cone, the height of which equalled the diameter of its base, diminished the resistance of the air only half, it may serve to shew that the statements of those who have given currency to the opinion that we may be conveyed at *any* velocity on railways, are promulgated by persons who pronounce upon questions without examining them: since, in addition to this resistance of the *air* to the locomotive engines themselves, would be its resistance to the tenders, and coaches or waggons they drew;

* Dr. Hutton, at the end of a table of resistances to bodies moving through still air, at rates varying from two to thirteen miles an hour, says, "The resistance to the same surface is nearly as the square of the velocity; but gradually increasing more and more *above* that proportion as the velocity increases."

and that, too, independent of, and additional to, the resistance opposed by the *railway* friction of the engines, tenders, and loads, behind them.

That something of this kind prevents *very* high velocities from being attained on railways, is evident. At the locomotive engine competition on the Liverpool and Manchester Railway four years ago, velocities of from 35 to 40 miles an hour, were attained by engines which were not one-tenth the power of some of those now used; while, at the opening of that railway, three years ago, the engine by which the surgeon was brought to Mr. Huskisson, after his deplorable accident, went 15 miles in 25 minutes, which is at the rate of 36 miles an hour. Yet do not the so much more powerful locomotives now used on that road, go faster than this: a circumstance which may prove that the limit to the velocity of railway conveyance, will arise from a source not calculated on.

"But," it may be observed, "this objection to the possibility of very high velocities on railways, is counterbalanced by the dilemma in which you place yourself, by supposing it to be possible that any such power as that of 29,196 horses, can, at one time, be made to operate on a tunnel; since, as relates to practical application, it would prove 'an impossible quantity.'"

The inference I deny; and, when necessary, will disprove.* But the term I accept; and will avail myself of, to shew that it is equally "an impossible quantity" that even if a tunnel were ten times as long as one between Manchester and Liverpool, the friction of air which is caused to move in it, in consequence of exhaustion taking place at the opposite end, can ever oppose an impediment such as is here adverted to.

According to the opinion that the friction of the air would increase as the square of the velocity, the friction of the column of air, which, when moved by exhaustion at the rate of 20 miles an hour, in a tunnel eight feet diameter and a mile long, was 288lbs., would, when moved at the rate of 80 miles an hour, be 4608lbs.; which, on the whole area of the tunnel, would be equal to 1.3 inches of mercury. Therefore, supposing that at every mile of a tunnel extending from Liverpool to Manchester, barometer tubes were to be inserted, the bottoms (or basin ends) of which should be open to the atmosphere, and the tops open to the inside of the tunnel, the mercury in each successive tube would (reckoning *towards* the end at which the exhaustion took place) rise 1.3 inches higher than that in the preceding.

Now as 1.3×23 gives 30, while 1.3×30 gives 39, it appears that at 23 miles from that end of the tunnel at which the atmosphere was admitted, and seven from that where the exhaustion took place, there would be such a vacuum as would raise mercury the *whole* height of the barometric column; while, at the end of the 30 miles there would be—or rather *ought* to be, according to this calculation—39 inches of mercury; or a vacuum and a third; which, in addition to its being "an impossible quantity," places those who contend that the resistance of the friction of air which is caused to move through a tunnel by the pressure of the atmosphere in consequence of exhaustion taking place at the opposite end, increases according to the square of the velocity, in the dilemma of assuming that there is a certain place in a tunnel 30 miles long, where, notwithstanding that a

* A hint on this point. The engine with which Watt first proved his principle was not equal to a *dog*'s power. There is one now in Cornwall said to be of 1000 horses power.

In our first steam-boats, engines of only two or three horses power could be employed; and the proposition to use larger ones was met by the usual exclamation, "Impossible!" We have now many steam vessels in which engines of 200 horses power are employed; while there is one in which they are above 300 horses power.

man, a horse, or even an elephant, might walk as freely and unobstructedly along, as a mouse could through a rat-hole, that subtle, permeating, and all-pervading element which we breathe, would, like the stream of the Jordan when under the influence of the miracle by which the Israelites passed over that river, stop, stick fast, and be unable to move farther; a position, which necessarily throws us for an escape from this dilemma, on the conclusion that, though it is certain that the friction of air against the inside of the tunnel will be an impediment, and though it is probable that this impediment will be of some importance, yet must it be equally certain that it will not be the serious impediment which it is *supposed* it will prove: and it may therefore, safely be assumed, that the objection which presents an insuperable obstacle in the minds of the many who have condemned the method of operation by exhaustion which I propose (because they deemed it analagous to operating per plenum) becomes removed, and is found to be what all the other "insuperable objections" which have been arrayed against the proposition are found to be when grappled with; i. e. baseless and unreal; it being necessary only to put a valve at every half, or quarter of a mile, which should be opened by the carriages as they passed, to render the length of the column of air of the natural density, which *must* be behind the carriages to drive them along, only a few hundred yards, and its friction consequently unimportant; said valves being (as can easily be done) so arranged, as to close themselves again the moment the carriage had arrived at, opened, and passed by, the next succeeding one.

But though I freely admit that the friction of the air against the inside of the tunnel may waste power to a degree which shall prove not unimportant, yet may it be doubted whether it will be more important than the waste of power occasioned by the present method of railway transmission by locomotive engines.

In the documents laid before the Lords' Committees on the London and Birmingham Railway, by the Treasurer of the Liverpool and Manchester Railway, on the 28th June, 1832, it is stated that the "number of trips of thirty miles" performed (or travelled) by the locomotive engines between Liverpool and Manchester, in the half year ending the 31st December, 1831, was "5392": which, as the same document shews that the *whole* amount of profitable weight conveyed over those 30 miles during that half year was less than 91,000 tons, gives an average of only 17 tons as the profitable weight carried each "trip." The weight of the engines by which these loads were drawn it may be difficult to fix upon: though, as the locomotives now used on that railway, are, some of them, above six tons, others above eight, and others above ten tons in weight, it may, perhaps, be fair to take eight tons as the average weight. The weight of the tenders with fuel and water, appears to be rather a delicate subject. The weight of the tender of the Rocket, with its load of fuel and water, at the grand locomotive engine competition in October, 1829, was three-fourths that of the engine itself. There have since been many accounts of immense loads drawn on the railway, of which those by Dr. Lardner, in his "Lectures on the Steam Engine," are considered as "by authority." But though we find the weights of the engines, as well as of the loads, and various other particulars (even to the state of the wind) given, yet does it happen that the weights of the tenders, with their supplies of fuel and water, are "unascertained" and omitted, throughout. Under these circumstances, I can do no other than act on the best information I have obtained, and suppose the weight of the engines and tenders with their cargoes of fuel and water to be twelve tons for each "trip."

Assuming it to be so, the weight of the moving power will be above two-thirds of the profitable

weight conveyed; while, supposing the same proportion to obtain as to the 4000 tons just mentioned, the amount of the effect of the friction of the power by which they were conveyed at the rate of 20 miles an hour, would be twice and a half as much as the friction of the air would be in a tunnel when twice the tonnage was conveyed from Liverpool to Manchester in it, at the same rate; which, for equal quantities, is five times the friction while, as relates to the fuel consumed, it would be *very* many more times than this, dearer.

There is one class, who, above all others, might derive benefit from properly considering what I thus submit, relative to the friction of the air.

When what was termed "the railway mania" was at its height, it was calculated that no body of men would be so much benefited by it as the iron trade; in proof of which the following statement was circulated:—

"We are authorised to state, that the rail-roads already projected, will require considerably more than two millions of tons of iron. Now, as iron has recently advanced from 7*l.* to 14*l.* per ton, it appears that the iron masters (by the way, the originators of, or principals in, many of these schemes) will receive from the subscribers twenty-eight millions sterling."

But, instead of the iron trade having been benefited by the principal portion of what is expended on railways being for their article, scarcely more than one-twentieth part has been expended for iron; the remainder having gone for labour in "cutting and embanking," &c. &c.

In the account in Mr. Treasurer Booth's book, of the expenses of the Liverpool and Manchester Railway, the line which, in the statement, runs "Iron rail account," gives only 66,830*l.* as paid to the iron masters: the other hundreds, which make up the aggregate of 67,912*l.* there mentioned, being for "oak plugs, freights, and cartages;" which is little more than one-twentieth part of the whole that has been expended on this railway.

The rails of the London and Birmingham Railway are to be half as heavy again as those of the Liverpool and Manchester Railway. Yet does the expense of the "rails, chairs, keys, and pins," in the estimate of that railway laid before Parliament, amount to only 212,940: one twelfth, that is, of the two millions and a half, which form the aggregate of the estimate there given in.

One of the inducements which railway advocates have held out to the landed proprietors of the Houses of Parliament, in order to lead them to support railway bills, has been the degree to which poor rates, &c. would be diminished, in consequence of the labourers there would be employed in digging out the earth for the cuttings and embankments, in the different parishes through which the lines of railway would run; and in the papers of the end of June and the beginning of July (1832) is a *very* long advertisement of the London and Birmingham Railway Company, one part of which states that "The *landed interest* will be benefitted by the expenditure of *upwards* of two millions of the capital of the Company in labour."

According to their own shewing, therefore, the expenditure for the benefit of the landed interest will be "*upwards* of two millions," while the cost of the iron rails, &c. will be only upwards of two hundred thousand pounds. And as both this, and other advertisements, and the evidence before Parliament, announce the extension of the railway from Birmingham to Liverpool, when this first half of it from London to Birmingham is done—which extension will be about the same length as this first half—the statements of the railway advocates themselves, give the iron masters to see, that the result of the time, trouble, and expense, which they (the iron masters) have devoted to

bring forward railways, is, to put more than a shilling into the pockets of the agricultural interest (by the degree to which they will save parish rates, &c. &c.) for every farthing they put into the pockets of the iron masters themselves; all that is saved to country parishes, being actual gain to the agricultural interest; while the 12th or 16th paid to the iron trade is for value in iron; out of which the usual trade profit is all that the iron masters will gain. In other words, about four millions sterling will be paid *for* the parishes between London and Liverpool, in the shape of wages for labourers, while only about four hundred thousand pounds will be paid *to* the iron masters for the iron rails, &c.; out of which the iron masters will have to pay the wages of their men who smelt &c. the iron, and the royalties (or rent) for the ore, coal, &c. &c. used in making it.

The difference there is in the specific gravities of ore, coal, and limestone, in different places, will render any estimate *not* correct for every place; though, generally speaking, I believe it may be received that the quantity of iron stone, coal, and lime stone, which it is necessary to raise to produce a ton of pig iron, will be about 6¼ cubic yards.

In the evidence laid before the Lords' Committees upon the London and Birmingham Railway, it is stated that the whole amount of "earth work" required for that railway, amounts to 22,779,431 cubic yards; of which a detailed statement is given in the minutes of evidence.

Dividing the twenty-three (nearly) millions of cubic yards of "earth work" which are to be excavated and embanked on the Birmingham Railway, by the number of cubic yards of ore, &c. which it is necessary to dig to make a ton of iron, will show, that if the wages which will be paid for levelling on that railway, were to be expended in digging iron ore, &c. the nation would be benefitted by having three millions and a half tons of iron more than it now possesses; while the labour expended on the railway will be not only worth nothing to the nation, but also worse; inasmuch as it appears by the evidence before the Lords' Committees that it will render 1250 acres of land, which are now cultivated and productive, sterile as a turnpike road.

It is supposed by Mr. Treasurer Booth, in his book on the Liverpool and Manchester Railway, that three thousand miles of rail-road, will, eventually, be laid down in England.

Supposing these 3000 miles to require "earth work" (cuttings and embankments, i. e.) in the same proportion that the London and Birmingham Railway will do so, and also supposing that the wages which will be paid to the Irish, &c. labourers, who do the digging for this "earth work," were, instead, to be paid to the workmen of the iron masters for raising ore, &c. &c. and converting it into iron, the nation would be richer by nearly one hundred million tons of iron, than it will be if these said wages are paid merely for "cutting and embanking" for railways.

Now though I do not mean to insinuate that this hundred million tons of metallic worth, would increase what is now termed the "monetary wealth" of the nation, yet, as surely as their ignorance (and consequent want) of iron, rendered Mexico and Peru such easy conquests to the iron of the Spaniards, as to make them most striking examples of the truth of Solon's warning to Croesus, "He who has more iron, will soon be master of all this gold," so surely would the possession of this hundred million tons of iron, be enormously more advantageous to the nation, than the cuttings and embankments required for these 3000 miles of railway will be.

Although iron be not, at the present day, either with ourselves, or in any other part of the world, the symbol of value, medium of exchange, and *money*, which Lycurgus made it in Sparta, when that state was in her glory, yet has it, as a commodity which will obtain us the gold and

silver of Mexico and Peru in exchange for it, a value, which will procure us the amount of its worth in those metals, as certainly as any other commodity that we export. In whatever proportion, therefore, this hundred million tons of iron would procure us either the gold or silver, the corn and flour, the silks and cottons, the wines and wools, the tea and coffee, the sugar and spices, &c. &c. of other countries, would devoting the wages which will be expended in cutting and embanking for these 3000 miles of railway, to the raising and smelting of iron ore, be more valuable to the nation at large, than if so employed.

Nor is this all; since the substitute I propose for railways, would give us food for one hundred thousand people, which these railways will deprive us of.

The documents laid before the Lords' Committees, state, that this Birmingham railway will cover and throw out of cultivation, 1250 acres of land. Supposing the proportion thrown out by the 3000 miles of railway to be the same, the whole amount will be 33,333 acres. Allowing these acres to produce three quarters of corn each, is no very excessive allowance.* And each individual of the kingdom being estimated to consume a quarter of corn every year, here is land that would produce bread for one hundred thousand people thrown out of cultivation by the railway system.

Now as, in addition to its being perfectly *practicable* for my tunnels to be buried underground, it would be decidedly best for themselves, and for the operation of the principle, that they should be so; and as ploughing, sowing, reaping, mowing, and all other operations of agriculture, may go on over them, as over any drain, or water-pipe, there is, in addition to the *metallic* difference which my plan would make to the riches of the nation, the circumstance, that, besides providing this exchangeable metallic wealth, or exportable value, it would also provide us, every year, with food for one hundred thousand more people, than the railway system can provide for.

The *metallic* part of the question being, however, that which concerns the iron trade, I will keep to that.

One of my early views of this method of conveyance, was, that it *might* prove important to the iron trade, from the much greater quantity of their production which it would consume, than railways require: and it has, for these seven years, been an object with me, to awaken the attention of the iron masters to (as I conceived) its importance to them, and to endeavour to convince them of the propriety of giving to a plan, which would consume *tons* of their article, where railways consume only hundred weights, the same fostering and support which they gave to bringing forward railways.

But it has not pleased the iron masters to see the case in the same light in which it presented itself to me.

It is well known to them, that in the year 1810 we had neither a steam-vessel nor a gas-work in the kingdom: the propositions to adopt both those important inventions being *then* termed and treated, just as this proposition of mine is now termed and treated, i. e. as "impossible, absurd, and madness to think of." Yet have they seen that a sum of (roundly speaking) ten millions, has, since that period, been sunk in the construction of gas-works and steam-vessels.

* The average produce per acre, throughout the island, is estimated at 2½ quarters for wheat, 4 for barley, and 4½ for oats; average, 3$\frac{2}{3}$rds.

With proofs such as these before them (and which have led to the consumption of so much of their production as gas-works and mains require), that, what they, a few years ago, deemed utterly impossible, may, nevertheless, be quite the reverse—it might have been supposed that the iron masters would not prove, either incredulous to, or bigotted against, the belief that a still more important extension of the use of their article was about to open to them.

But, to my great surprise, I have found, that of all unbelievers, the iron masters have proved the most unbelieving.

Other people doubted only because the want of knowledge on the subject, which they openly avowed, left them no alternative. But, in the iron masters, I have had "to contend with the pride of false knowledge." The world at large said, "We cannot believe, because we cannot understand." But the iron masters say, "We do not believe, because *we* know better."

On asking them how and why they "knew better," I found that it was not, as some might suppose, from any doubt or difficulty as to the tunnel itself; which they admitted could be cast and laid down, of any size or dimensions that might be required. Neither was it from any doubt as to steam-engines or air-pumps being large and powerful enough to do what was necessary;—the tens of thousands of gallons of air ejected per minute, from the air-pumps which they use to blow the fires of their smelting-furnaces, and the hundreds of horses power they know steam-engines are made equal to, removing all question on these points.* But their incredulity arose from a difficulty which one of them had met with, in forcing air through a pipe; and of which they supposed me ignorant; but to which I had adverted, in a publication years before, in the following words:

"It is too well known, to be at all affected in point of veracity, by an inability to mention either the exact time or place, that the proprietor of an iron work in Wales had, some years ago, occasion to erect an additional furnace, at the distance (recollection states) of about three-quarters of a mile from his old ones. The blast apparatus of these old works being large enough to supply this new furnace in addition to the old ones, he conceived it would prove much cheaper, if, instead of having power and blast cylinders erected at the new work, he were to lay a pipe from the old ones, to convey to the new one the superfluous blast. This he accordingly did; and as soon as the pipe was completed, set the apparatus going, to ascertain the strength of the blast he could thus apply to the new furnace. To his great surprise, however, no blast was produced; a gentle current, which would hardly blow a candle out, being all that was perceptible. For a result so adverse to his expectation, he could account in no way but by supposing that, from accident or design, the pipe was stopped up. As the readiest way to ascertain whether it was so, he put a cat in at one end, and blocked it up, leaving her to find her way to the other.

Thus situated, puss had no alternative but that of seeking an exit at the other end: this she accordingly did, and, contrary to his expectations, soon made her appearance there. Convinced

* "*Steam-Engines.*—It has been ascertained that there are now in Great Britain not less than 15,000 steam-engines at work; some of almost incredible power. In Cornwall there is one of one thousand horses power."—*New Monthly Magazine, for July*, 1831.

Independent of the large air-pumps which the iron masters themselves use, those I put up to exhaust air from the tunnel which I constructed at Brighton would, if worked at an extraordinary rate, have pumped five hundred thousand gallons per minute through it.

by this that the pipe was not stopped up, he concluded that the disappointment he had experienced arose from the friction of the air against it; and finding that he could in no way obviate this difficulty, he was obliged to abandon the design, and be at the additional expense of blast apparatus for his new furnace.

"Now, had the proposition this treatise submits, been, that we should convey ourselves through a tunnel such as has been adverted to, by employing apparatus on the principle of blast furnaces, to blow us through, by *forcing* air in behind us, the circumstance which has just been stated would be fatal to that proposition. But when, instead of being blown through, by air *forced* in behind us, it is proposed to cause the air which is behind the vehicle to operate to push it forward, in consequence of some being taken from before it, the case is widely different. Air which is forced to move in a pipe, in consequence of other air being driven into that pipe behind it, operates (in degree) as a wedge, and opposes to the power which moves it, resistance, arising from becoming, as it were, wedged against the pipe, through its whole length. But air which, instead of being *forced* to move by an impulse from behind, that, as it were, wedges it against even the very end of the pipe it enters at, is *allowed* to move, owing to some being taken out from before it instead of being forced in behind it, becomes affected as any thing from which a wedge is *withdrawn* is affected; that is, freedom of motion is allowed, and its parts play so much more freely, that friction is diminished instead of increased. The impediment would prove, therefore, less important in this case than in the other, even were there no method of altogether obviating it; happily, however, the means of doing this are in our power. Between driving a vehicle through the proposed tunnel by forcing air in behind it, and according to the method which has been stated, there is this difference, —that in the former case the impulse can be given only from the end where the moving power operates; while, in the latter, arranging valves, which should be opened by the vehicle as it passed over them, would admit of that impulse being renewed at every hundred yards, could it be necessary to do it so frequently. Let the friction of the air against the pipe be what it may, therefore, a valve at every mile, or at every half or quarter of a mile, which (as may be done) should be opened by the vehicle as it passed along, and caused to remain open till it (the vehicle) had arrived at the next valve, would prevent any diminution of the velocity at which we might be conveyed, that would prove important."

"This reasoning may be illustrated by a figure relating to an experiment. Air was forced through a pipe 56 feet long, at the rate of 20 miles an hour, under a pressure which is equal to 2.2 inches of water; and as it required a pressure which is equal to 0.6 inches of water to make air move at that rate through a hole in the side of a vessel, there was consequently 1.6 inches greater pressure at that end of the pipe at which the air entered, than at the end from whence it issued.

"Now if the length of the pipe—the tenths of pressure at the entering—and those at the issuing end, be expressed by two lines approximating each other, as shewn below, it may be conceived how "air which is forced to move in a pipe in consequence of other air being driven into that pipe behind it, operates as a wedge; and opposes to the power which moves it, resistance, arising from becoming as it were wedged against the pipe, through its whole length."

"Since the length of these two lines bears the same proportion in hundredths of an inch to 56 feet, as the spaces between the ends of them bear (in tenths of an inch) to 2.2 inches of water, and

0.6 inches of water;* and if we conceive that forcing air to move in this way, is, in some degree, analogous to drawing an elastic endless rope, the size of which should be equal to the larger end of the pipe, through it, and out at the smaller end, we may form some idea of the degree to which power would be absorbed in operating by a plenum. And not only this; since, reversing the operation, and supposing the rope to be drawn from the smaller to the larger end, will also give us some idea of the effect of operating by exhaustion, or vacuum; and enable us to conceive that "air which is allowed to move, owing to some being taken out from before it, instead of being forced in behind it, becomes affected, as any thing from which a wedge is withdrawn is affected; that is, freedom of motion is allowed, and its parts play so much more freely, that friction is diminished instead of increased."

Unconvinced, however, by arguments of this kind, the iron masters persist in maintaining what I propose to be impossible, because one of them found that the *exactly reverse* process is so. In other words, they act just as those "impossibleists" did, who, in their ignorance that high steam would admit of the vacuum, air-pump, ponderous condensing chest, and ton of cold water per horse power per hour, which are inseparable from low-pressure engines, being dispensed with in high-pressure engines, pronounced it to be utterly impossible ever to make steam-engines capable of running upon roads, because such engines could neither carry the ponderous apparatus inseparable from the condensor, nor the immense quantity of cold water required to produce the vacuum which, alone, renders low-pressure engines efficient.

In vain did I point out to them, not only that I had not overlooked their objection, but that my earliest views of the subject, had adverted to, and expressly guarded against it. It was of no use: for no "Demetrius" or other "craftsman" of that day ever vociferated, "Great is Diana of the Ephesians!" more perseveringly, than the principal iron masters of the present day have exclaimed in honour of the idol "Impossible," whom it pleased them to set up and worship, in opposition to the (as they deemed it) heresy I presumed to attempt to teach them.

Had they done me the honour to *prove* me heretical, and that theirs was the *true* faith, I should have been importantly benefitted, as well as convinced: insomuch as it would have prevented me from devoting at least seven additional years of time, and all the means in my power during that period, to the subject. But when they would not trouble themselves to *examine*, and condemned, solely because they proclaimed "impossible," a method of operation, which I not only did not advocate, but which my publications proved I had long and openly disclaimed, I could not but feel, first, the truth of Dr. Robertson's observation, "As in Genoa ignorance had opposed and disappointed Columbus, in Lisbon he had to combat with prejudice, an enemy no less formidable;" and, secondly, that just as the reasoning of the pilot who was chosen to execute the treachery planned against Columbus, failed, because he had courage only to go half-way, so did the reasoning of these gentlemen fail, because they have done only *half* what is necessary to disprove the practicability of what I propose.†

* For the sake of the plain reader it necessary that the scale of length should be in hundredths of an inch; but as the effect would have been imperceptible had the same scale been observed, tenths are adverted to for it.

† Having performed what was due to his country, Columbus was so little discouraged by the repulse which he had received, that, instead of relinquishing his undertaking, he pursued it with fresh ardour. He made his next overture to

In publications, besides that just quoted, I have not only stated my conviction that the method of operation which the iron masters condemn would be impracticable, but also have endeavoured to analyse the question, and show *why* it would be so. But as I do not, like them, stop there, and (in effect) say that it must ever be impossible to discover a "North-West Passage," or reach the *North* Pole, because Captain Cook could not get within 30° of the South Pole, these gentlemen are pleased to act the part of "Alexander the coppersmith," against me, rather than to give themselves the trouble of examining whether the part of another Alexander might not prove more honourable, as well as more advantageous to them.

The quotation given a few pages back, states that the price of iron was raised from 7*l.* to 14*l.* in 1825, in consequence of what was then called "the railway mania." But, so far from maintaining this price, the following extract from a Memorial, which was agreed to at a meeting of the Staffordshire Iron Trade, held at Dudley, on the 4th October, 1831, shews, that in six years the price of iron had fallen lower than ever before was known.

"Memorial to the Right Honourable Earl Grey, First Lord of His Majesty's Treasury.

"We, the undersigned Iron Masters, of the Staffordshire Iron and Coal district, think it our duty respectfully to represent to His Majesty's Government the following facts:

"1. That for the last five years, ever *since what is called the panic of* 1825, we have found, with very slight intermissions, a continually increasing depression in the prices of the products of industry, and more particularly in Pig Iron and Bar Iron, which have fallen respectively from upwards of 8*l. per ton* to under 3*l. per ton*, and from 15*l. per ton* to under 5*l. per ton*.

John II. king of Portugal, in whose dominions he had been long established, and whom he considered, on that account, as having the second claim to his service. Here every circumstance seemed to promise him a more favourable reception. He applied to a monarch of an enterprising genius, no incompetent judge in naval affairs, and proud of patronising every attempt to discover new countries. His subjects were the most experienced navigators in Europe, and the least apt to be intimidated, either by the novelty or boldness of any maritime expedition. In Portugal, the professional skill of Columbus, as well as his personal good qualities, were thoroughly known; and as the former rendered it probable that his scheme was not altogether visionary, the latter exempted him from the suspicion of any sinister intention in proposing it. Accordingly, the king listened to him in the most gracious manner, and referred the consideration of his plan to Diego Ortiz, bishop of Ceuta, and two Jewish physicians, eminent cosmographers, whom he was accustomed to consult in matters of this kind. As in Genoa, ignorance had opposed and disappointed Columbus; in Lisbon, he had to combat with prejudice, an enemy no less formidable. The persons, according to whose decision his scheme was to be adopted or rejected, had been the chief directors of the Portugnese navigations, and had advised to search for a passage to India, by steering a course directly opposite to that which Columbus recommended as shorter and more certain. They could not, therefore, approve of his proposal, without submitting to the double mortification, of condemning their own theory, and of acknowledging his superior sagacity. After teasing him with captious questions, and starting innumerable objections, with a view of betraying him into such a particular explanation of his system, as might draw from him a full discovery of its nature, they deferred passing a final judgment with respect to it. In the mean time, they conspired to rob him of the honour and advantages which he expected from the success of his scheme, advising the king to dispatch a vessel secretly, in order to attempt the proposed discovery, by following exactly the course which Columbus seemed to point out. John, forgetting on this occasion, the sentiments becoming a monarch, meanly adopted this perfidious counsel. But the pilot, chosen to execute Columbus's plan, had neither the genius, nor the fortitude of its author. Contrary winds arose, no sight of approaching land appeared, his courage failed, and he returned to Lisbon, execrating the project as equally extravagant and dangerous."—*Robertson's America, Vol. I. p.* 86—88.

"2. Against this alarming and long-continued depression, we have used every possible effort in our power to make head. We have practised all manner of economy, and have had recourse to every possible improvement in the working of our mines and manufactories. *Our workmen's wages* have, in many instances, been GREATLY REDUCED, and such reduction has been attended with, and *effected by, very great suffering and distress*:—but the royalties, rents, contracts, and other engagements, under which we hold our respective works and mines, have scarcely been reduced at all, nor can we get them effectually reduced, *because the law enforces their payment in full.*

"3. The prices of the products of our industry having thus fallen within the range of the fixed charges and expenses which the law compels us to discharge, the just and necessary profits of our respective trades have ceased to exist: and in many cases a positive loss attends them.

"4. Under these circumstances, we have long hesitated in determining what line of conduct our interest and our duties require us to adopt:—If we should abandon our respective trades, our large and expensive outlays in machinery and erections must be sacrificed, at an enormous loss to ourselves, and our honest and meritorious workmen must be thrown in thousands upon parishes, already too much impoverished by their present burdens, to support them:—and if we should continue our respective trades, we see nothing but the prospect of increasing distress, and certain ruin to all around us."

The remaining part of this "Memorial" touching on politics, need not be quoted here.

If the iron of the 3000 miles of railway which Mr. Treasurer Booth, in his book on the Liverpool and Manchester Railway supposes may eventually be laid down in England, should be of the same weight which I understand that of the Birmingham Railway is to be, the whole quantity consumed will be about 800,000 tons. Supposing an equal application of the system here advocated, and that only ten times as much iron should be used in the tunnels as is used in the railways, eight millions of tons, instead of eight hundred thousand, will be the aggregate consumption.

Now as iron, though unquestionably the best, is neither the only, nor the *cheapest* material of which tunnels can be constructed, it may not, possibly, be unpardonably presumptuous in me to submit to the iron masters, that if they persist in doing, by this proposition, as the Genoese did by that of Columbus, they will also lose an opportunity, which would, to them, prove equally important, as would have been that of Columbus to Genoa.

I *have* asked, and I *still* ask of them only one thing: a full, and *fair* investigation. By the result of that I am content to abide; though I must, in common justice stipulate, that this investigation shall be entered on in a different spirit to what it has hitherto been my lot to meet with. "There is always a proneness" says Washington Irving, "to consider a man under examination as a kind of delinquent, or impostor, whose faults and errors are to be detected and exposed." Most truly can I say that I have "*always*" experienced the effects of this "proneness" in reference to this subject: and that the object of those who deemed my proposition worthy throwing away a fragment of their time upon, was infinitely less to ascertain its truth and justice, than to display their own penetration and wit, in discovering and turning to ridicule, every part which admitted (as they thought) of being sneered at and made the subject of a jest.

Had it been my good fortune to have met with but one candid examinant of influence, I had been spared years of trouble and anxiety. But my proposition being deemed deserving only of

contempt, candid examination has no more been vouchsafed me, than to the wanderings of a lunatic.

Should, however, the iron masters, instead of granting me this candid investigation, continue, "in the pride of half knowledge," (as Dr. Wells terms it) to condemn what I propose, because they have found that a something has failed, which is as different from it, as would be, saying that it is impossible we can ever get to the North Pole, because Captain Cook could not get within 30° of the *South*, I venture to commit myself to the prediction that they will repent it, as bitterly as Genoa repented her rejection of Columbus's proposition, to discover, and possess her of America.

"They inconsiderately rejected his proposal, as the dream of a chimerical projector," says Dr. Robertson, of the Genoese, "and lost, for ever, the opportunity of restoring their commonwealth to its ancient splendour."

For, equally certain as it is that iron, though the best, is not the *only* material of which tunnels can be constructed, is it, that unless this proposition is very differently treated by them to what it has hitherto been, will they drive the manufacturing of tunnels from their own line into another: and that, too, notwithstanding that opportunities are arising which, in addition to bringing them to their own doors, would give such facilities as relates to the transmission of the large stocks of iron which the uncertainty, and occasional long interruptions of the present method of conveyance, compel them to keep in London, as to do away with the necessity for keeping those stocks.

The Welch papers announce the plan of a railway which is to connect the iron districts and ports of that country with London. In this plan, Merthyr Tydvil, the centre of the South Wales iron manufacture, is stated to be 176 miles from London.

Now, even supposing that this railway, instead of costing the *many* thousands per mile which it must cost, could be laid down for nothing, still, the circumstance of the *bare expenses* of conveyance on the Liverpool and Manchester Railway, amounting to $4\frac{1}{4}d.$ per ton, per mile, exclusive of the charges necessary to pay one farthing of interest, or return on the capital sunk in laying that railway down—and for which $3\frac{1}{4}d.$ per ton, per mile, is charged, in addition to the $4\frac{1}{4}d.$ required to cover the *bare expenses*—the mere *expenses* of railway conveyance, *exclusive* of interest or return on the capital invested, being so great as this, it appears that, even were this railway laid from their own doors to the metropolis, the iron masters could not, including the charge to pay interest or return upon the money sunk in laying the railway down, get their material to London for less than 4*l.* 10s. per ton; which, on an article the selling price of which (pigs) in London is only about the same amount, is in effect a prohibition; especially with the expense of freight for coast conveyance, only 12*s.* per ton from South Wales to London.

But as the expense of carriage by a tunnel would be as much less than this over-sea freight, as that is less than railway conveyance; while, in addition to this superiority over both, a tunnel would save all the *risk* as well as the delays and uncertainty of over-sea transmission, London and the iron districts might be brought within so few hours of each other, as to obviate the necessity of the iron masters keeping the heavy stocks of their article in London which they are now obliged to maintain, and the capital so locked up become, in consequence, liberated for other purposes: while, were the tunnel extended to Milford Haven, as it has been announced the railway would be, that port, as well as Swansea, might be brought within a few hours of London; and the advan-

tages of its (perhaps) unequalled harbour, rendered fully available to the nation at large for commercial purposes, as well as to Government for our fleets.

This consideration merits the serious attention of the advocates of the Bristol Railway. Swansea and Milford Haven being *both* more advantageously situated for all vessels from foreign ports that would make Bristol their port of delivery; and their harbours being (particularly the latter) incomparably superior to that of Bristol, a tunnel would, were it to be laid down between either of them and the metropolis, be the certain ruin of any *railway* from Bristol to London. The mere *expenses* of carriage on the Liverpool and Manchester Railway being $4\frac{1}{4}d.$ per ton per mile, and the *whole* charge 8*d.*, it is evident that, supposing the Bristol Railway were to cost only *half* what the Liverpool and Manchester has cost (the "Capital, 3,000,000*l.*" placed at the head of the prospectus of the Bristol Railway, allows 25,000*l.* per mile for each of the 120 miles the map accompanying said prospectus shews the line will be in length) the whole charge for carriage along its line could not be less than 6*d.* per ton per mile: the aggregate of which, 8*l.*, would be equal to what cargoes have been brought from the East Indies for; and more than equal to freights from the West Indies, Mediterranean, &c. &c.; so that only such cargoes or freights as stress of weather drove into Bristol, would be sent to London by the railway; while, by a tunnel from Milford or Swansea, they might be sent so cheaply, as actually to command the trade which it is *supposed* the Bristol Railway will command.

But to return from the long digression, into which the consideration of the question relative to the effect of the friction of the air, and the importance of the subject to the iron trade, has led me.

Supposing the possibility of the Liverpool and Manchester railway proving a failure, that company would have scarcely any more *saleable* value in their possession, in exchange for the million and a quarter which it has already cost, and the million and a half which it *will* cost them, than the (about) 5000 tons of iron which is in their rails. Their long, narrow, slip of ground, dear as it has been to them, would be worth nothing; while the labour of taking up the between two and three hundred thousand stone blocks (or bases) they have laid down to carry the rails, would be more than those blocks are worth. Also would the 450,000*l.* expended in levelling the line *and forming the road*, be utterly lost.* Whereas, had a tunnel been laid down, not only would the whole of the hundreds of thousands expended in levelling have been saved, but as not one-tenth of the labour would have been required to lay a tunnel down, compared with what the railway required, a large sum would have been saved for that also; while what *was*

* Items: up to the 31st May, 1830.

| | £. | s. | d. |
|---|---|---|---|
| Bridge account | 99,065 | 11 | 9 |
| Fencing | 10,202 | 16 | 5 |
| Chat Moss account | 27,719 | 11 | 10 |
| Cuttings and Embankments | 199,763 | 8 | 0 |
| Formation of Road | 20,568 | 15 | 5 |
| Land account | 95,305 | 8 | 8 |
| | £.452,625 | 12 | 1 |

And this, exclusive both of the 300,000*l.* (nearly) which has been expended since, and of the 130,000*l.* which is the *estimated* expense of the tunnel now in course of construction.

laid out, being for *metal*, instead of labour, there would have been from ten to twenty times more saleable value in their hands, than they now have.

And as the same circumstances would, in a similar case, apply to the Birmingham, and Bristol (and indeed to *all*) Railways, as well as to your line, it would, comparatively, be almost as much better, in this particular, to have a tunnel instead of a rail-road or canal, as it would be to hold specie instead of paper, during a run on the bank: though this advantage would be greatest in relation to a canal; the greater proportion of the expense of which, is for that *irrecoverable* outlay, labour.

In point of the friction of the wheels would the carriages that moved in the tunnel be importantly superior to railway carriages.

Owing to circumstances which it is not necessary to discuss, the height of the wheels of the coaches and waggons on railways is confined to about three feet. Wheels of twice that diameter have been tried, but thrown aside in consequence of their liability to cause accidents by running off the rails: the only thing by which the wheels of all vehicles running on edge railways are kept on them, being a rim, which, projecting *one inch* beyond the bearing part of the tire of the wheels, keeps them on the rails; as the brim of a hat will keep the body of it from rising on a table, over the edge of which said brim hangs.

In consequence of this, all carriages running on open railways are liable to accidents, such as those mentioned in the notes below, *many* of which have occurred; though, owing to their having happened either in the excavations, on the levels, or on the low embankments, the dashings-to-pieces which *will* take place when they occur on the high embankments have, hitherto, been avoided.*

But as the carriages inside the tunnel *cannot* get off the railway in it, as they do on common railways, while, owing to the constantly vertical position in which the wheels can be kept, they may be twice, or three times, as high as on common railways, so great a diminution in the power required to move any load will take place, as to admit of any weight being moved in the tunnel with less than half the power required to move it on the Liverpool and Manchester Railway.

In point of repairs, too, would the tunnel be importantly cheaper than a railway. Supposing you were to have a railway, there would be, in every mile of it, above seven thousand stone blocks, or bases, to carry the rails; every one of which bases would be liable to sink, and disarrange the

* "*Railway Accident.*—We are sorry to have to mention a very serious accident, which occurred on Saturday, on the railway between Kenyon and Bolton. The locomotive engine was going up the lower inclined plane, with a heavy load of goods, and at the turn-off at Colonel Fletcher's colleries, ran off the road, and was unfortunately overturned against a bank, and fell upon the engineer and fireman, who were killed on the spot. Two other men were riding on the tender, one of whom was dangerously hurt, the other scalded. This engine, we understand, was the only one which was ever worked on a railway with wheels of six feet diameter; and, on that account, had never been allowed to take the coaches."—*Times, 26th July*, 1831.

"On Wednesday morning, the engine drawing the first-class train of carriages from Manchester to Liverpool, on the railway, had the misfortune to break an axle-tree, when at full speed, near Chat Moss; which, after ploughing the ground for some time, went off the rails, and drew the whole train over the embankment†, when, most providentially, out of two hundred passengers, not a life was lost, or a limb broken. Several persons were bruised, and some seriously."—*Morning Herald, 9th December*, 1831.

† There, only a foot or two above the ground.

level of the line, as they are so constantly doing (vide page 11); while the rails themselves would be liable to bend, and break, between these bases. Sinkings of the bases, and bendings and breakings of the rails, &c. &c. being (like fractures of the harness and apparatus of stage-coaches, or the ropes of ships) matters of constant occurrence, there are, in the whole, and including *every* liability to disarrangement and repair, above eighty thousand parts or places, in every mile of the Liverpool and Manchester Railway, where adjustment or repair *may* daily be required; while, were that railway to be made a quadruple one, by having two more lines of road (four more lines of rails, i. e.) laid down, these liabilities would increase to above one hundred and sixty thousand per mile; though, for the present, I refer only to fractures and loosenings of the chairs, &c. bendings and breakings of the rails, and sinkings, &c. of the bases, which are *now* possible to the amount of above 40,000 per mile; whereas, in a tunnel, the corresponding disarrangements would be possible to the amount of only 1056 per mile: an advantage which time will prove to be of much greater importance than it may at first be considered; owing to the small expense of repair it will occasion. Supposing the London and Birmingham Railway were to have the "quadruple line" adverted to when the capital was raised to three millions, there would, in its whole length, be nearly twenty millions of parts or places where repair, or adjustment, *might*, daily, be necessary: a number which might well double the 488*l.* per mile, per annum, charged under the item "Maintainance of way," in the half-yearly accounts of the Liverpool and Manchester Railroad.

But neither is this the last circumstance with respect to which a tunnel would be superior to a railway.

From the statements laid before Parliament, it appears that in the half-year ending the 31st December, 1831, "the number of trips of 30 miles" made on the Liverpool and Manchester Railway was 5392. Now as the *whole* weight carried during this half-year was *under* 91,000 tons, it appears that the average *profitable* weight (passengers, or merchandise) carried each trip, was *less* than 17 tons.

The average weight of an engine and its tender, with fuel and water, being, I believe, not less than 12 tons, while there is the weight of the coaches and waggons additional to this, it would appear that for every ton which pays any thing, that is carried on the Liverpool and Manchester Railway, they also carry a ton which pays nothing.

Now, owing to the manner in which the carriages that move in the tunnel can be constructed, and owing to there being no locomotive engines, and tenders carrying fuel and water, required to move them, this proportion of dead and unprofitable weight will be so much reduced, as for it not to amount to more than one-fifth of the similar weight on the railway.

The *whole* expense of conveyance on the Liverpool and Manchester Railway during the six months ending the 31st December, 1831, was, it appears by the statement laid before the Lords' Committees on the London and Birmingham Railway bill, fourpence farthing per ton, per mile; while the whole *charge* for it was eightpence per ton, per mile. Coal being nearly ten times dearer here than it is there, there is no reason to suppose that what it might cost you for conveyance along a line of railway would be less than this; while it may be presumed that it would be so much more as, perhaps, and of itself, totally to counteract the advantages afforded by the shortness of your line, compared with the present route.

In addition to the advantages which I have stated a tunnel would hold out to the Company I

have the honour to address, there would be one of a peculiar nature. It is generally understood, and appears from evidence to be the fact, that a considerable portion of the income of the Liverpool and Manchester Railway Company has arisen from persons who have visited and paid for riding over their line, solely from curiosity; while it is well known that the income derived from visitors to their tunnel, by the Thames Tunnel Company, is considerable; the average annual amount having been 1200*l.* per annum.

The curiosity excited by the public relative to the tunnel I constructed at Brighton, surprised me. Thousands manifested a desire to see it: hundreds applied to be permitted to do so; and when they found I would not let them, offered guinea after guinea to be allowed to gratify their curiosity, under the idea that mercenary motives gave rise to the orders I left that *no one* should be admitted; while many of the very highest rank (including *every* class of our nobility) made personal application to me to oblige them with a sight of it.

As I could convey persons in your tunnel (supposing you were to have one) most safely at the rate of a mile in a minute, and as a velocity of that kind being attained near the metropolis, by a method so novel as this, would induce very many thousands to visit and ride through it for curiosity, it may be expected that a considerable part of what it would cost to lay a tunnel down would be returned from this source; enough (in the end) I am bold to say, to pay for the cost of the iron whereof it would be constructed.

The Thames Tunnel, supposing it never should be completed, will for years bring in the 1200*l.* per annum, which is the average of what has been received from people visiting it; and I am fully satisfied that proper measures would, in the end, bring in, from this source alone, perhaps, more than would cover the cost of the iron, of which the tunnel I propose to you would be constructed.

In the prospectus of the Greenwich Railway Company is the following paragraph:—"Moreover, when it is considered that the population of London, Westminster, and the Borough, is about one million and a half, and that the population of the surrounding towns and villages, within a circuit of from forty to fifty miles round the Capital, amounts to nearly double that number; and that, in short, the number of persons visiting London during each year, make up a total exceeding five millions of persons, it is not unreasonable to expect that, through mere curiosity alone, two millions of persons will gratify the same, when it can be accomplished at a low price, suppose only one shilling, to go and return,—yet if so, that item alone would produce 100,000*l.*

Now, as supposing that the curiosity excited by my *novel* proposition, will produce only one quarter of what the Greenwich Railroad Company calculate may come into their pockets from the same source, will, I think, be allowing sufficient pre-eminence to the *superior* curiosity which an old method of conveyance *must* excite, I trust that my idea, that the cost of the iron composing the tunnel may be repaid from this source, will be considered a not immoderate one.

In the Thames Tunnel there is nothing but the bare arch to see; while in this there would be the tunnel itself, the largest air-pumps, &c. &c. in the world, and a ride to and fro at the rate of sixty, or more, miles an hour.

Nor would the objection which, it may be imagined, must arise from the want of daylight in the tunnel, prove an objection in point of fact. So trifling is the degree of exhaustion and pressure required to move a load of 100 tons, that, but that the advantages which would arise, as relates to cheapness of site, and evasion of opposition on the part of the land-owners and occupiers, from

carrying the tunnel under ground, prevent it, I could window light the tunnel throughout its whole length: that which I constructed at Brighton having light admitted into it through windows of common thin glass; strong plate-glass not being required. Indeed, so far as relates to possibility, the upper half of the tunnel might be one continued window (like the top of a green-house), throughout its whole length. But as, even if this was done, artificial light *must* be had for sixteen hours out of the twenty-four in the winter; as the tunnel might be gas-lighted throughout its whole length; or as, instead of thus wasting light unnecessarily, each carriage might carry lights before and behind, the objection that the tunnel being underground would render it dark as midnight, is no more a serious objection than it would be, were the Thames tunnel finished, that it would be better to cross the river by London Bridge, than through that tunnel, because on the bridge you would have *natural*, while in the tunnel you must have artificial light.

It is true that there could be no "view of the country" by this method of conveyance. But, as the object of it is the perfection of travelling, in the three particulars of safety, expedition, and economy; as even the comparatively low rates attained on the Liverpool and Manchester Railway prevent objects that are by the road-side being distinctly seen, owing to the velocity with which the passengers are whirled by them; and as the much greater velocity at which conveyance may be effected in the tunnel, would render any attempt to look on what was *passed* productive of the effects experienced by a child who looks on the ground while leaning out of the window of a coach, no *real* loss, as relates to "seeing the country," would result from transmission taking place inside the tunnel instead of outside it: though, even if it should, it might be submitted to, when economy of both time and money, and complete obviation of the dangers attendant on breaking down, being overturned, run away with, or driven against any thing, became the equivalents.

Have we occasion to travel to Edinburgh by the mail, we unrepiningly submit to the inconvenience of passing two nights (32 hours in mid winter) not only in total darkness, but also "cabinned, cribbed, confined" to a degree which prevents us even from "changing a leg," except by previous arrangement with our opposite fellow-passenger. But when it is proposed that we shall go in vehicles which, in addition to being as large and commodious as the cabins of many steam-vessels, will be as much shorter a time in going, as they are larger and more convenient than the inside of mail-coaches, and in which the most brilliant light may be enjoyed, we proclaim it to be "impossible" to consent to go by such vehicles, because they would move inside a tunnel: not considering that this very circumstance, of being *inside* said tunnel, would as certainly secure us from being overturned, driven against any thing, run away with, breaking down, or any other of the dangers to which turnpike-road travelling is liable, as it would give us the ease, comfort, and accommodations of the cabin of a steam-vessel, instead of the privations and endurances experienced in mail-coaches.

And as the valves which have been adverted to as fixed at every quarter, or half, or whole mile, would, in point of effect, be doors, by means of which exit from the tunnel could be effected, the bugbear of being "shut up in a tunnel many miles long, with no place to get out of it, if any thing should happen," need not be seriously replied to.

Such are some of the benefits which laying down a tunnel, instead of a railway would procure you. But the most important of all is yet to be mentioned.

As it does not follow that, because you may think proper to lay a railway down, the public

will think proper to use it, it becomes vital to your interest, that some inducement which shall lead them to use it, and cause them to prefer the more circuitous route to the Birmingham Railway by your line, to the more direct one by the Edgeware Road, should be laid before them. This inducement will be furnished by the tunnel which I propose to your adoption.

The carriages which would go in said tunnel may be rendered so superior in point of size, of the room they will give to each passenger, of comfort, and of general accommodation, as to be comparable to the cabin of a steam-vessel, rather than any thing else I can liken them to.

In one of those used in the tunnel I constructed at Brighton, above twenty people have sat with a table between them, covered with provisions, plates, dishes, &c. &c. and taken as ample a meal as was perhaps ever eaten; so that accommodations (even to that of a sofa for each person) which could not be thought of in coach or omnibus travelling, *might* be given to passengers.

Owing also to the size and construction of these carriages admitting of my using the air for springs, their motion would be soft and (as relates to the avoidance of all jolting) air-balloon-like, to a degree which you cannot conceive; and which no railway carriage, far less any common road vehicle could compare with.

In point of safety, too, would they be incomparably superior; since, instead of being liable to break down, to be driven against any thing, to be run away with, or to be overturned, &c. &c. these accidents would be so impossible, that absolute immunity from danger, and certain security to life and limb, would be consequent on this method of conveyance; while the rate of transit under which this safety would be secured, being so great as to admit of the journey being effected in as few minutes as you thought proper, your route might be rendered as much shorter as you pleased in point of time, than the route by the Edgeware road could be rendered. The expense of the power too, by which your passengers would be conveyed, being above twenty times cheaper than coaches or omnibuses could convey them along the Edgeware Road, you would have a still greater advantage in this particular. It remains, therefore, only to point out how the public may be caused to take your circuitous line, in preference to the nearer route by the Edgeware Road.

In order to effect this, and to save the public from having to go from Hyde Park Corner to your line, as must be done were you to lay a railway down, I propose bringing your line to Hyde Park Corner, by extending the tunnel; branching it eastward from your basin, either through Kensington and Knightsbridge, under the turnpike road; or (in order to avoid all interference with, or opposition from, the Turnpike Commissioners) along the shorter line across the vacant grounds to the south of the road, at the back of Kensington and Knightsbridge; across (though beneath, and indeed underground all the way) Earl's Court Lane, Gloucester Road, Grove Lane, the Brompton Road, and Sloane Street, to the vacant ground on the North and East of Wilton Crescent.

I am not, at present, prepared to point out either the best route, or the best spot, for the termination towards Hyde Park Corner; having investigated only so far as to satisfy myself that such a course is practicable.

You will, at first, be startled at, and disposed to object to this extension, because you will suppose that it involves the outlay which would be required for two additional miles of tunnel, without bringing in any more return than would be received from passengers to the Birmingham Railway. This conception, however, is an erroneous one.

Were a method of conveyance in operation, by which the inhabitants of the west end of Kensington, of Earl's Court, of North End, of Walham Green, of Brook Green, of Hammersmith, of Turnham Green, of Chiswick, &c. &c. could be carried (more safely than by coaches) from your basin to Hyde Park Corner in two or three minutes, instead of the twenty minutes or nearly half an hour which it now takes to get over that ground, they would so prefer your method of conveyance, as to render the additional outlay required for said two extra miles of tunnel, the most remunerating portion of your whole line; while, in addition to enabling you thus to convey passengers, said branch would enable you also to deliver coals, and other goods at Hyde Park Corner from your canal, for an expense of less than a penny per ton carriage from your canal thither; so that you would rival the Grosvenor Canal, and add importantly to the tonnage trade of your own canal by it.

Should the Birmingham and Bristol Railways be completed, this branch would also enable you to convey goods, as well as passengers, to and from them, and to and from the western parts of town, more cheaply than could any how else be done; an accommodation which laying down your railway could not give. And as I *could* so construct these two extra miles of tunnel as to render their cost—the cost of the tunnel itself, i. e.—not more than about five thousand pounds per mile, the expense of this branch would not prove any ruinous addition to your contemplated outlay.

Therefore, for these reasons, I recommend you to prevent its being necessary that people should pay omnibus (or other) proprietors, to carry them from Hyde Park Corner to your basin at Kensington, in order that you may *then* convey them to the Birmingham (or Bristol) Railway, by extending your line towards Hyde Park Corner, in the way I have adverted to.

Your case, brought into a focus, is as follows. You have expended a large sum in opening a line of conveyance which, owing to its not being carried far enough at first, does not combine all the advantages your situation admits of being combined. You are, naturally, desirous that it should do this. If you open a communication for goods with the Grand Junction Canal, by extending your own canal, you will do this in degree. You have, therefore, for some years, contemplated carrying your canal up the height between your basin and the Grand Junction. But the enormous expense of this has prevented you from doing it.

Being now informed that your object may be better effected by a railway, you entertain that idea; and as, were you to lay a railway down, passengers, as well as goods, might be conveyed by it, you are desirous of, if possible, bringing the "passenger trade," between the Birmingham Railway and the west end of London, to your line.

Owing, however, to the distance of your line from the west end of Town; and to the Edgeware Road, offering a shorter and cheaper communication from the Birmingham Railway to that part of the metropolis, your laying down a railway, will, for the reasons I have pointed out, certainly prove a losing speculation.

As the method I propose would be most importantly cheaper than a railway, in point of first cost, and still more importantly cheaper in point of current expenses, I venture to offer it to your notice. And as it would obviate the objection which your distance from Hyde Park Corner would occasion, supposing you were to have a railway, I presume to recommend it to your consideration, as more worthy notice than any thing else you can have laid before you; for the reasons, that it will, in the first place, be much cheaper in point of first cost than any other method of conveyance,

you can lay down: second, because it will be still more economical in point of current expenses: third, because, in addition to being incomparably safer, as relates to life and limb, than any other method of conveyance, it will be so much more expeditious as to render your circuitous route quicker, *in point of time*, than the shorter route by the Edgeware Road, as well as cheaper, in point of charge: and, fourth, because it will be productive of an important profit, additional to, and exclusive of, what a railway will bring in; and which will return no inconsiderable proportion of what it costs to lay it down.

Were the statements I have given relative to the cost and expenses of a railway, from my own estimates only, they might be doubted by you. In order, however, to avoid this, I have been careful to quote only the "evidence," which was laid before Parliament, and other documents; which leave no doubt that the first cost and current expenses will be, at least, *equal* to what I have stated, though they by no means prove that they will not be *more*.

Indeed, it appears susceptible of proof that they will be more. Mr. Graham, in his "Letter to the Traders and Carriers on the Navigation, connecting Liverpool and Manchester," relative to that railway, says, "I pledge myself, however, to prove (in case the fact be denied by the Directors) that the aggregate expenditure of the half year, ending on the 31st December, 1832, bears a higher proportion to the income of that period than the expenses of *any* preceding half-year bear to the income of the same.

Mr. Graham also says, "The Railway Corporation keep two separate accounts of expenditure, "*ordinary*" and "*extraordinary.*" The "ordinary expenditure" is paid from the annual returns received from working the railway; and the "extraordinary" is paid by borrowing money, or a creation and sale of shares; which is termed "adding to the capital account." The ordinary expenditure, only, affects the dividend; and it is the interest of every one concerned to make *that* expenditure appear as low as possible; and, whenever the outlays are commingled, or doubtful, to throw the burden on the obnoxious shoulder. This "extraordinary outlay," or, as it is termed, "outlay on the railway and works," or "Capital Account," has been as great since the railway was opened, as during the period when it was forming. The amount thus laid out in the first fifteen months after the opening of the railway, amounted to nearly 200,000*l.* The outlay on this account in 1832 is not stated; but the interest on borrowed money paid in that year, is given as 10,522*l.* 10*s.* 6*d.*, while the interest paid in 1831 was only 5647*l.* 7*s.* 6*d.*"

Railway advocates may dispute this; but *that* I shall not heed. Should they, however, *disprove* it, I shall not be able to deny that I am liable to the censure due to him who investigates in the spirit of a partisan, rather than in that of a candid examinant.

It may be objected, in answer to the advantages which I have stated would result from your substituting this Pneumatic Railway for the common railway you contemplate, that you have never heard of it before, except in the way of ridicule and contempt; while not only have the engineers of the day condemned it, but also do even some of yourselves entertain doubts as to the sanity of the man who can propose such a thing to you.

In allusion to objecters of this latter description, the M. D. who did me the honour to propose the first Resolution at the "Town Meeting" at Brighton, said, in the course of his speech on the occasion, that "Mr. Vallance had had to contend with the greatest difficulties; such as were enough to appal any man: he had been derided and ridiculed: his system had been treated as

visionary, theoretical, and fantastic: he had been called a wild projector—nay, some had even gone so far as to say that he was mad. If so, he (Dr. Yates) must say, with Polonius, "there was method in his madness." And to such insinuations he (Dr. Y.) would reply, in the words of Hamlet, there was that which "sense and sanity scarce could be delivered of."

With my defence against insinuations of this kind thus provided, I may turn to the more serious objections of the engineers whom you may consult: who, I am well aware, will treat the proposition only as Brindsley's proposal to carry the canal over the Irwell, was treated by the engineers of his day.

Were this any thing new, I might feel it. But when we have it on record that the professed engineers of the period have done the same by *every* proposition that has been brought forward, until its being established by others, caused them to see that money might be made by imitating, instead of continuing to decry the inventor, their exclamations of "impossible," "absurd," and "madness to think of," may well be disregarded.

Had Telford, or Stevenson, or Rennie, or Brunel, or any other first-rate man, originated the proposition, then, indeed, they might have had some faith in it! But for an unknown nobody to do such a thing, is of itself enough to prove that it *cannot* be worth attention.

To these gentlemen I reply, by asking them—to whom are we indebted for the steam-engine in its application to steam-vessels, and locomotive purposes, as well as a first mover for machinery? Savary, its first inventor, was a miner. Newcomen and Beighton, its first improvers, were, one of them a country blacksmith, and the other a plumber, while its grand improver, the great Watt, was a mathematical-instrument maker. To whom are we indebted for our canals—for our nationally-important cotton machinery—for the public application of the gas-light principle—for the system of railway transmission—for the hydrostatic press—and the other manifold improvements, which have raised us to the station we fill? Is it to men, who, at the periods when these improvements were first devised, were of high name, and established reputation as civil engineers? Hear what one whose situation enabled him to decide, says on the subject:—

"What has been the means of raising our native country to that eminence in civilization which renders her the admiration of the world? Her improvements in the arts and sciences.

"From whom have those improvements chiefly sprung? From men who have emerged from the humbler walks of life.

"What was Sir Richard Arkwright; a man to whose genius this country is indebted for very much of its commercial prosperity; to whose improvements in the machinery for spinning cotton, we are indebted for being enabled to keep the cotton trade chiefly confined to ourselves. What, I say, was the great Arkwright? A barber. Yet do we owe our proud superiority in this department of our national greatness to the unassisted efforts of Dick the barber.

"Who was Ferguson? A simple peasant; a man, who, wrapped in his plaid, passed the winter nights on the ground in contemplating the heavens; and who, by arranging his string of beads on the cold heath, at length completed a map of the stars, and raised himself to the knowledge of our late sovereign.

"Who was Dr. Herschel, the discoverer of so many important astronomical facts? A boy who played the pipe and tabor in a foreign regimental band. Who was the great Watt? A mathematical instrument maker.

"Who was Smeaton, the builder of the Eddystone lighthouse, and the first engineer of his day? An attorney.

"Who was the great Brindsley, whose canals have given such an accession of power to our commerce, by the facilities of internal communication? A country millwright.

"Nicholson was a cabin boy: and Ramadge, the best maker of reflecting telescopes in the world, was a cutler."

In continuation of this list of "nobodies," to whom we owe so much of our national greatness, I ask, to whom are we indebted for the very inventions which the engineers of the present day claim as their own, with justice equal to that wherewith the organ-*blower* considered the tones of the instrument *his?*

Railways have been in use among us for a century and a half; and, notwithstanding that those of this remote date, were no more comparable with those of the present day, than the matchlocks of the same period are with a modern gun, the *principle* was equally developed in the one case as in the other. Yet is there no engineer who can claim the credit of having said "As this principle admits of most important benefits being conferred on society, provided it is worked out, and carried to the perfection it admits of, I will devote myself to such working out and perfecting."

Locomotive engines have been seen among us for these thirty years. Yet did the engineers of the present day no more perceive and seize *their* advantages than they did those of railways. But, after the perception and talent of various persons, who were in business, had, for the purpose of adapting them to the necessities of their different trades, so improved railways and locomotive engines, as to have rendered the latter capable of running *regularly* upon the former, at rates of from five to eleven miles an hour, forth came our engineers, and, claiming both inventions as their own, set themselves up as having enlarged the boundaries of science, enabled man to outstrip the fleetest animals, and almost to vie with the winds!

And, last of all, I ask, to whom are we indebted for the latest important discovery, by which unprofessional perception has shewn, that what *every* engineer of the present day had pronounced to be, not only a mathematically-demonstrated, but also a *practically*-proved "impossibility," is as perfectly, and as easily practicable, as it was for Columbus to make the egg stand on its end.

We have nearly 3000 miles of canals in the island; the draught on which being twenty times easier than on common roads, and the "wear and tear" equally less, it has, ever since they were first cut, been an important object to render the rate of conveyance along them rapid enough to induce persons to travel from place to place *on* them, as well as to send their goods by them.

This became more particularly important, when, in consequence of the rapidity attained on railways, it was found that they could combine the conveyance of passengers with that of goods; and I do not hesitate to say, that any engineer, who had, in 1825, informed the Canal interest that he had discovered a method by which conveyance could be effected on canals at the same rate as by mail-coaches, or post-chaises on turnpike-roads, and for one-tenth of their expense of draught, might have made terms with them for the adoption of this method, which should have brought him in above 100,000*l.* sterling.

But, so far from the engineers of the day informing the canal interest that they could do any thing for them in this case, they universally preached despair with respect to it; satisfying them, by mathematical demonstration, that, owing to the resistance of fluids to bodies moving through

them, increasing according to the square of the velocity, rapidity of transmission along canals was no more possible than for a coal-barge to beat to windward like a cutter.

It is true they admitted that the steam-engine gave them power enough to move vessels on canals as rapidly as steamers move on rivers. But, they said, owing to the surge, which it was *unavoidable* such rapid motion *must* create, the banks of the canals would be so soon washed down, that it was impossible to avoid ruining the canals, if rapid conveyance were attempted on them. Therefore, though steam has been in use as a moving power on our rivers for above these twenty years, it has never yet been employed for a similar purpose on our canals, except in the way of experiment.

In consequence of these things, they could do nothing to meet the wishes of the canal interest: and, in the evidence on the Birmingham Railway, before the Lords' Committees, on the 29th June, 1832, it is stated, in answer to an inquiry as to what was the quickest kind of canal communication between London and Birmingham, that "The fly boats go by the shortest route, and *they* are three days and three nights on the road." Now as this "shortest route" is 152¼ miles, it appears that the quickest rate of canal conveyance by "fly boats" was then less than 2⅛th miles an hour; while in answer to the question, "What time is occupied by the slow boats?" it is replied, "About six or seven days: they seldom travel at night."

In this state of despair on the part of the canal interest, and amid this chorus of "impossible," on the part of the whole of the engineers of the present day, a private gentleman (William Houston, Esq. of Johnstone Castle) became impressed with the opinion that, equally as we can, by giving it rapid motion, cause a flat stone to skim over the surface of the water (as boys do, when playing at what they call "making ducks and drakes") so might we, by giving rapid motion to a flat-built boat on a canal, cause it, not only to skim *over* the water, so as to avoid raising the wave which the engineers had pronounced equally unavoidable as it would be fatal to the banks of canals, but also much more easily than boats can be drawn *through* the water.

On putting this thought into practice, Mr. Houston found the result to be what he had anticipated; and the consequence is, that it is now established by actual and *daily* practice on the Paisley and Ardrossan Canal, that boats which carry *more* passengers than (on an average) the locomotive engines, of twenty and thirty horse power each, draw on the Liverpool and Manchester Railway, at rates of from 15 to 20 miles an hour*, are drawn from Johnstone to Glasgow at the rate of ten miles an hour by *two* horses only; while a velocity so high as 15 miles an hour has been attained: "and this speed was not limited by *the labour of the draught*, but by *the power of speed* of the horses."

In other words, that which the whole of the engineers of the present day had pronounced and *demonstrated* to be utterly impossible, is now constantly done, several times every day, as a regular passenger-carrying business, on the Paisley and Ardrossan Canal.

And, although the charges for this rate of conveyance are "just one-half, and one-third, of the fares in the Liverpool Railway coaches, the profits are such, as to have induced the proprietors to quadruple the number of boats on the canal;" while the passengers, instead of being boxed up as

* The average number of passengers drawn by the locomotive engines between Liverpool and Manchester during the most successful half year since that railway has been opened, is 87 each journey.

These boats can and *have* carried 110 passengers at one time, though 100 may be considered an average number.

n the railway coaches, and exposed to the weather, as in the railway "second class carriages," may either take exercise on the decks, or seat themselves in the long cabins of these passenger-boats.

As this method of rapid canal conveyance is becoming generally adopted, this simple idea of a private gentleman, has not only put to shame the whole of the engineering talent of the present day, but has also possessed the kingdom of nearly 3000 miles of liquid way, which, as if by the stroke of a wand, are raised from the low value of heavy, miry, cross country roads, on which no greater velocity than that of a carrier's waggon could be attained, to the high value, not merely of the best turnpike-roads, on which the conveyance of persons, at mail-coach and post-chaise rates, can be effected, but also of routes on which two horses can (and daily do) draw one hundred people as fast and (I understand) *more* easily than four draw sixteen persons on our best mail-coach roads, with less than one-twentieth of the wear and tear to the vehicle, than takes place as to coaches on roads: an advantage, the money value of which will be inadequately expressed by saying, that as it would cost above thirty thousand pounds per mile to give us roads on which the same power could do the same work, with the same small expense of wear, tear, and current expenses, the simple thought of a private gentleman, whom the engineers of the day would have pronounced a "nobody" in point of scientific authority, has possessed the nation of what it would have cost above one hundred millions sterling to purchase, had said engineers been employed to procure an equal amount of roads, of equally easy draught, and little "wear and tear" for us.

Yet are these gentlemen looked up to as infallible; and allowed to fulminate their anathemas with respect to what they please to pronounce "impossible" as if they were omniscient.

The actual charges by the passenger-boats, which now run daily (at the rate of ten miles an hour) between Johnstone and Glasgow, are, one penny per head per mile in the first cabin, and three farthings per head per mile in the second cabin.

How much less these charges are than turnpike-road fares, need not be pointed out: my object being to submit, that equally as our canals having for these three-quarters of a century remained only routes for goods at carriers'-waggon rates, when they might, all along, have been routes for passengers at the highest rates whereat it is possible for horses to go, proves that the engineers of the day knew nothing whatever of a subject which they professed *fully and entirely* to understand —so may they be equally ignorant of the merits of the proposition which they have so ridiculed and condemned me for presuming to bring forward; and which is, as exactly what *they* term it, as they *demonstrated* it to be "impossible" to be conveyed at mail-coach and posting-rates along canals.

Now, great as is the honour due to the engineers of the present day, for thus permitting the accidental thought of a private gentleman to possess the nation (as it were by the stroke of a wand) of 3000 miles of liquid way, over which conveyance may take place, at rates of from 10 to 15 miles an hour, for one-tenth the expense, and less than one-tenth of the wear and tear that takes place on roads, after they had *demonstrated* that no greater rate than two or three miles an hour could be attained on said routes; and, greatly as the canal interest must be indebted to them, for suffering them (the canal interest), in consequence of said *demonstration*, to lose the millions upon millions they might have received of the public, for conveyance at these rates of 10 or 15 miles

an hour, during the three-quarters of a century canals have been in operation among us—equally as the engineers *have* deserve public gratitude, do they also deserve it for the manner in which they have suffered the law of motion, by means of which the stage-coachman "swings" his vehicle up the first part of a hill, to remain useless with respect to that improvement of our turnpike-roads which it admits of; and which, though not equal in money-value to the "idea" of Mr. Houston, which has just been described, is yet highly important.

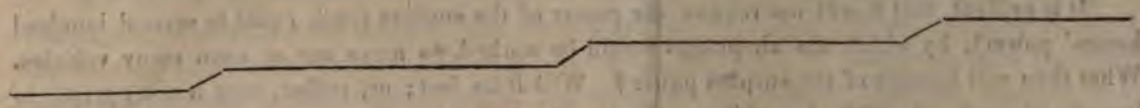
The law itself is "old as the hills," and, notwithstanding that the advantage taken of it by stage-coachmen when coming to the bottom of a rise, is not *quite* of such long standing, yet is it old enough to have pointed out an advantageous alteration in the arrangement of all our turnpike roads, had the engineers under whose direction said roads were laid out, but availed themselves of it.

By the table given on page 33 it appears, that if a vehicle be moving on a level with a velocity of 2¼ miles an hour, its momentum will (under the circumstances there stated) carry it up a rise of three inches in perpendicular height: while, if the rate of motion be twice, and four times 2¼ miles an hour—i. e. 5½ and 11 miles—the momentum will carry it up heights of one foot and four feet respectively: and the following table gives the altitudes due to every intermediate mile of rate:

| Bodies moving on levels at the undermentioned velocities, the motions of which are changed from horizontal to ascending, by means, either of angular or circular ascents, | Have momenta, which (friction being counteracted) will cause them to rise to the undermentioned heights above the level where those velocities were attained, let the rate o' rise, or angle of ascent, be what it may. | |
|---|---|---|
| MILES PER HOUR. | FEET. | INCHES. |
| 3 | 0 | 3½ |
| 4 | 0 | 6½ |
| 5 | 0 | 10 |
| 6 | 1 | 2½ |
| 7 | 1 | 7½ |
| 8 | 2 | 1½ |
| 9 | 2 | 8½ |
| 10 | 3 | 4 |
| 11 | 4 | 0 |
| 12 | 4 | 9½ |
| 13 | 5 | 7½ |
| 14 | 6 | 6½ |
| 15 | 7 | 6½ |
| 16 | 8 | 6½ |
| 17 | 9 | 7½ |
| 18 | 10 | 9½ |
| 19 | 12 | 0½ |
| 20 | 13 | 4½ |

A velocity of six miles an hour being thus capable of giving momentum sufficient to enable any vehicle to surmount an ascent of above one foot in perpendicular height, let the angle of ascent

or rate of rise, be what it might, it has been necessary only to lay out our turnpike-roads in alternate short levels, with sharp rises of one foot in height between them, similar to the line below,



to render all our roads level, in point of effect, to every vehicle which went at the rate of six miles an hour; since, as the *continued* draught of the horse would overcome, neutralise, and (as relates to its counteractive effect) annihilate the friction of the wheels and axes during the ascent, the momentum imparted by that velocity would enable the vehicle *of itself* to rise up, and surmount the ascent, without any *extra* effort on the part of the horse: while, supposing that the practice of stage-coachmen were to be imitated, and the horses of these six-miles-an-hour vehicles pushed to a space of twelve miles an hour for a few yards before the wheels actually touched these rises, so as to give the vehicle a velocity of 12 miles an hour at the moment of its *beginning* to ascend them, the momentum imparted by this velocity would carry the vehicle up four feet nine inches perpendicular, instead of one; so that the road might be laid out in alternate levels and rises of four feet.

It is true that, supposing the principle to be acted on, half the width of the road must be left in the usual manner, in order to enable waggons, which do not move faster than two or three miles an hour to pass over it. But as the slow rate of two miles an hour will give momentum enough to admit of a rise of $1\frac{5}{8}$ inches being surmounted, the principle might be taken some advantage of, even on the half of the road appropriated to waggons; since rises not exceeding $1\frac{1}{2}$ inches each, could be surmounted by vehicles which did not move faster than two miles an hour.

However, leaving the waggon-half of the road to the usual arrangement, the advantage of, as it were, doing away with all hills and rises, and rendering all our roads (in point of effect) level to all vehicles travelling at the rate of six miles an hour, would have amply repaid the expense of this suggested alteration in the *form* of the roads, had the engineers under whose direction they were cut, but laid them out in that manner: while, supposing that a rate of 16 miles an hour could be attained by pushing the horse to a gallop *just before* reaching the ascent, the levels and rises might be laid out in gradations of eight feet each instead of four feet.

But, let the heights of these proposed rises be what they might, the advantage of (in effect) doing away with all hills and rises, and of rendering our roads level to us all over the kingdom would be attained; which would prove ample reward for varying the mere form of the roads, as would have been necessary; and would not, I think, have been unworthy the notice even of our omniscient engineers; notwithstanding that the way in and degree to which they have neglected and slighted this law of motion, with respect to its application to railways as well as to turnpike-roads, proves them, one and all, to have been equally percipient of its advantages as they were of the practicability of rapid conveyance on canals; and as they *are* of the merits of the method of transmission which the individual who has now the honour of addressing you is presumptuous enough to think deserving even of THEIR attention: there being no objection they can bring forward against it which cannot be replied to and refuted.

It being the property of air to neutralise or absorb a smaller portion of any impulse that may be imparted to it than perhaps any other medium nature offers us, the power of the steam-engines,

which operated on the air-pumps that exhausted air from the tunnel might be brought to bear, with almost undiminished energy, on the vehicles in it; and an effect in consequence produced, which we cannot, at first, conceive to be possible.

It is evident, that it will not require the power of the engines (each equal to several hundred horses' power), by which the air-pumps would be worked, to move *one* or even many vehicles. What then will become of the surplus power? Will it be lost; or, rather, may it not operate to increase the rate at which the vehicles will move? And if so, how many times will the rate at which we may be conveyed, exceed that at which we now travel, and what is the limit that will be attained in this particular?

It is well known that air will rush into a vacuum at the rate of nearly a thousand miles an hour. Now although it is no more expected we should be conveyed at any such rate as that, than it is intended we should be placed in a vacumm, yet are, both this almost inconceivable velocity, and what is generally expressed by the tern "vacuum," so connected with the subject of consideration, that it becomes unavoidable to advert to them, injurious as they must prove, and strongly as they will array our preconceived notions and prejudices against the proposition.

It cannot be denied that we have the power of laying down a tunnel, such as has been referred to, for any distance we please: and, though it may not be in our power so to connect the separate "lengths" or cylinders which compose it, as to render the joints perfectly air-tight against a vacuum, yet, with reference to the purpose here contemplated, every joint may be made practically "air-tight." Equally certain, as it therefore becomes, that we have the power of extending this tunnel at pleasure, is it, that the power of making and working any number of air-pumps, such as have been referred to, will enable us to exhaust from, and consequently cause air to rush through it, at rates so vastly exceeding any at which we now travel, that our preconceived notions and prejudices cause us to look on the proposition as both impossible and absurd.

One of the circumstances which at first strikes us as fatal to the proposition, is the inability to respire, which we all feel we should be liable to, if conveyed rapidly *through* the air. A moment's reflection will, however, enable us to see that this objection has no application whatever to the case. It is not proposed that we shall be conveyed rapidly *through* the air, but that we shall cause air, which we have first set in rapid motion, *to convey us along with it, as fast as itself goes:* a state of things so different from going through, or against, and meeting the air, that our supposed objection does not apply to the case.

Stating facts will, however, be the best way of settling this question; and for this purpose the experience of our aeronauts is referred to. Much as they have sometimes been inconvenienced from the rarity of the air, at the height to which they have ascended, yet have we never heard them complain of being unable to breathe freely, owing to the velocity with which they were carried along over the earth's surface, notwithstanding that they have been conveyed at rates of 70, 80, and, in one instance, 160 miles an hour. And why? because that which was the cause of motion went with them.—"I had not," says Lunardi, in his account of the first ascent ever made in England, "the slightest sense of motion from the machine. I knew not whether I went swiftly or slowly—whether it ascended or descended—whether it was agitated or tranquil, but by the appearance or disappearance of objects on the earth." Rapidly, therefore, as they have moved, yet have they felt as if in a calm. Now exactly similar in point of respiration, would be the feeling of those

who might be conveyed in the proposed tunnel. The air, being the cause of motion, must go, *at least*, equally fast as it drove them, and necssarily be, wherever they were. Let the rate of motion, therefore, be what it might, the feeling of those who experienced it, must prove that of being in a perfect calm.

Nor are the objections we at first conceive, relative to the effect which pumping air from the tunnel, and producing what only the word vacuum (inapplicable as it is) will enable us to convey the idea of, at all more tenable. The degree to which air would be exhausted from the tunnel might scarcely ever be sufficient to sink a barometer two inches lower than one exposed to the atmosphere stood at; so that even were we exposed to it no inconvenience would be felt.* But we never shall be exposed to it, any more than those who witness the cruel experiment of putting a mouse under the receiver of an air-pump, and then exhausting it, are exposed to what the little animal suffers. Between those who *see* and the poor creature which *feels* the effect of the apparatus, is the side of the receiver. And between the part of the tunnel in which the exhaustion, or rather the difference of density is, and the passengers in the vehicle, would be the *end* of the vehicle; so that though *close to them* would be an atmosphere rarer than (we will suppose) it might prove pleasant to be in, yet would the atmosphere *they actually were in* be the same as that of the air at large. No inconvenience, therefore, can be experienced in this particular.

Equally untenable is the idea we take up, that it will be impossible so to adapt the ends of the vehicles to the inside of the tunnel as to cause them to act as pistons in preventing the passage of the air by them, without occasioning friction, to a degree which should deprive us of all the advantages the air would otherwise give, as a mean of communicating motion.

In the last carriage which I had for the tunnel at Brighton, there was a space of above an inch and a half in width left all round between the *piston* part of the carriage and the tunnel; through which air rushed unimpeded. Yet did not this "windage," or leak, though equal, in the aggregate, to an aperture of three square feet, prevent the carriage from springing forward to the impulse of the air-pumps, with a readiness I was surprised at. Nor did it ever cause the least *perceptible* diminution in their effect; owing to the small quantity of air that passed through it, in comparison with the immense quantity exhausted by the pumps.

When the Brighton Committee rode in my tunnel, one of them brought with him a mountain barometer, that he might ascertain the degree of "vacuum" or exhaustion necessary to move the carriage. This barometer was accordingly suspended in the part where the "vacuum" was to be produced, and the vernier adjusted with the greatest accuracy. But to his surprise the degree of exhaustion was not sufficient to lower the barometer in the *least* degree. Being aware of this, I had spirit gauges previously prepared, one of which was fixed in the end of the carriage. But even this gauge, though nearly fifteen times more sensitive than a mercurial gauge, was affected hardly enough to be visible, the amount of "vacuum" indicated by it, being only about ten grains per square inch, or *less* than the ten-thousandth part of a vacuum.

Nor would the quantity of air that rushed by the *piston*-end of the carriage be at all important, even when travelling at *very* great velocities, and with heavy loads. In a tunnel of the diameter

* Air of only three-fourths, two-thirds, half, and in Joliffe and Cornillot's ascent, of less than half the usual density, (the barometer sinking to 12.15) has frequently been respired, without any serious consequences.

which would be proper for such lines as those to Bristol, or South Wales, the pressure requisite to move a load of 100 tons would not be more than about 100 grains per square inch; which would cause air to rush past the piston-end of the carriage at the rate of about 30 feet per second. Therefore, even could no better adjustment of the piston-end of the carriage and the inside of the tunnel be effected than took place with respect to that at Brighton, only 90 cubic feet of air per second would rush past, even were the carriages standing still; which is only one-tenth of what the air-pumps I used there were capable of exhausting in the same time; while, in such a line as the Bristol, or South Wales, it would not be one-hundredth of what the exhausting apparatus would take out in the same time; so that not one-hundredth of the power would be lost by it: and even this hundredth could easily be reduced to a thousandth: the space left between the piston-end of the carriage in the tunnel at Brighton being *purposely* an inch and a half in width, in order that I might shew by actual proof how utterly unimportant was that objection which engineers of the very highest name and importance had assured me must, *inevitably*, prove fatal to the motion of *any* carriage in *any* tunnel.

And as the carriage, instead of standing still, would be moving forward, loss of power, which would, otherwise, result from the pressure requisite to *give the velocity* as well as move the load, would be equally unimportant as that arising from the pressure requisite to move the load alone.

With pressures so trivial as this, capable of producing practical effects, and with it fully practicable so to adjust the "piston" part of the carriages to the tunnel as to render this "windage," or leak, perhaps less than one-hundredth of that which I *purposely* caused in the tunnel at Brighton, there can be no difficulty either in preventing any important quantity of air from rushing past the carriages; or on so connecting the "lengths" of which the tunnel would be composed, as to render the joints air-tight."

And as there are *no* objections which the engineers can bring forward that cannot be replied in an equally satisfactory manner, I need not trouble you with any additional answer to them.

It is just four years ago since the locomotive engine competition took place on the Liverpool and Manchester Railway. In all probability no proprietor of the Kensington Canal happened to be present at that contest; yet is it equally probable that all of you were as fully convinced of the fact from the accounts which appeared in the newspapers, as if you had seen it. Now though I cannot give the conviction arising from the evidence of your senses, yet can I give stronger evidence than the public vehicles of intelligence gave as to that competition, by referring you to the public authorities and records of Brighton, to know whether I did not carry an appointed number of its inhabitants to and fro, as the locomotive engine went during that competition; "when," says Mr. Treasurer Booth, in his "Account of the Liverpool and Manchester Railway."—"The prescribed distance, it should be understood, was, owing to the circumstances of the railway, obliged to be accomplished, by moving backwards and forward on a level plane of one mile and three quarters in length." I did not, it is true, carry those gentlemen so far as those engines went. Nor, indeed, was there any occasion for it. Had it been necessary, they could have continued riding to and fro in my tunnel as long as the locomotives ran to and fro on the railway. But, as when they had satisfied themselves that there was no trickery in the motion of the carriage, and that it was *really* moved by the air, they had, then, seen all that it was necessary to see to convince them that a longer tunnel would enable me to move a carriage equally far, as a longer railway would have admitted of

the locomotive engines going, they gave over riding, "because," as the Editor of the Brighton Herald says, in the extract which I have quoted from that paper, "because they became so convinced that the invisible and intangible medium we breathe might be rendered a safe and expeditious means of getting from one place to another, as to be tired of riding."

Were it necessary for your interest that a gas-pipe should be laid throughout the line you propose, your inquiry of the engineer you might employ would be, not whether the gas would pass through such a length of pipe, because you know that to have been long established, and to be every day acted upon, but what would be the *expense* of it; that is, it would be a money question, not a question of practicability.

The tunnel I constructed at Brighton was nearly eight feet in diameter, while the air-pumps I adapted to it were large enough to make an artificial wind blow through it at the rate of ten miles an hour. And doubling, tripling, quadrupling, &c. &c. the size, or number of the pumps, would have doubled, tripled, &c. &c. the rate at which this wind blew.

A common size for gas mains is eight inches. Were it propounded to you—"Can a mouse run through a rat-hole, let that hole be as long as it may?" your answer would not be dubious. Why, then, if it be proved, that we can, with pneumatic apparatus of an almost infinitely less efficient nature than that which I purpose using, make air move through smaller pipes five, fifteen, or even fifty miles long*, should any doubt be entertained whether air-pumps will cause it to move through one of eight feet in diameter; more particularly, when it is well known, that the larger the pipe the less the proportionate friction; and when your line will be little more than two miles long.

The pressure by which the gas is driven through the pipes of the work I know the most of, is equal to an ounce and a half per square inch. A similar pressure on the carriage in my tunnel would have moved above one hundred tons. The length of your line would be only about eighty times longer than the tunnel I constructed; and as the area of your tunnel would be nearly 150 times larger than the eight-inch mains through which the gas is carried many times farther than the length of your line, there need be no more question as to whether, or not, the principle will act throughout your line, merely because it is eighty times longer than my tunnel, than there is whether gas would pass through eighty lengths of gas-pipe.

And as the joints which connect the different "lengths" of gas-pipes can easily be made air-

* "Railroads, in many instances lighted with gas for a considerable distance (in one instance for sixteen miles) are, more or less, traversing every district of the country."—*New Monthly Magazine, July*, 1830.

"*The Liverpool and Leeds Railway.*—A bill is now under the consideration of a select committee of the House of Commons, for the purpose of connecting by rail-roads Liverpool with the ports on the Humber, and thereby to bring the German Ocean and the Irish Sea, the eastern and western sides of the island, within six hours' journey of each other. It is proposed to have four lines of railway, two for swift carriages, going and returning with light goods and passengers, and two for slower carriages, with heavy goods and animals. The whole is to be lighted with gas, so as to be traversable by night as well as day, and the plan of the iron rails will secure the carriages from obstructing one another."—*Times*, 17*th March*, 1831.

"The outline of a plan has been stated to us, for lighting up the intended line of railway from this city to London with gas. Our correspondent says, "Of the practicability of the thing there can be no doubt; and it certainly would be an improvement, and create a great demand for coals; as the gas might be continued from the parent line to any extent."—*Felix Farley's Bristol Journal*, 3*rd August*, 1833.

tight, so could the "length" and joints of the tunnel. "Under the trivial degree of exhaustion which will be necessary," says the Report of the Russian Engineer Officer, "rendering the tunnel sufficiently air-tight will be far less difficult than is at first supposed. Indeed, I see so many different ways of doing it," continues the Report, "that I am satisfied it would not, in practice, prove more difficult than, nor, indeed, so difficult as, causing some canals I have seen to retain the water let into them."

Following up the illustration which this gentleman thus gives, I beg to assure you I will guarantee that the tunnel shall not leak, or let air improperly in, so much as I see the basin of your canal leak water out.

Adverse as were the original circumstances of the great father of canal navigation in England, yet did he put to signal shame the opposition and predictions of the engineers who proclaimed him a madman for pretending that it was possible to carry a canal over a navigable river. Ten thousand times more mad as the engineers of the present day proclaim me, and a hundred thousand times more absurd and "impossible" as they have pronounced my proposition to be, yet, owing to my having in my favour (what Brindsley had not in his) the circumstance of my principle having been tried, I am enabled to oppose to their ridicule and sneers the FACT that I have proved it, on a scale, which, as relates to size, was fully, and in *every* particular practical; while it was less than practical in point of length, only because no individual could do that which it requires a public company and an act of parliament to do, that is, lay it down between places for actual trade.

Short, however, as it was, yet was it many times longer than the pipes through which gas was first carried, to prove the practicability of lighting our streets with that illuminator: while its length was great enough to be equally conclusive, as the movement of the first steam-vessel built by the introducer of steam-navigation.

"When," says Fulton, "I was building my first steam-boat at New York, the project was viewed by the public either with indifference or with contempt, as a visionary scheme. My friends, indeed, were civil, but they were shy. They listened with patience to my explanations; but with a settled cast of incredulity on their countenances. I felt the full force of the lamentation of the poet:

"Truths would you teach, to save a sinking land,
"All fear, none aid you, and few understand."

"At length the day arrived when the experiment was to be put into operation. To me it was a most trying and interesting occasion. I invited many friends to go on board, to witness the first successful trip. Many of them did me the favour to attend as a matter of personal respect; but it was manifest that they did it with reluctance, fearing to be the partners of my mortification and not of my triumph.

"The moment arrived in which the word was to be given for the vessel to move. My friends were in groups on the deck. There was anxiety, mixed with fear, among them. They were silent, and sad, and weary. I read in their looks nothing but disaster; and almost repented of my efforts. The signal was given; and the boat moved on a short distance, and then stopped—and became immoveable."

When *my* opponents can prove, that because Fulton's first steam-vessel would, on its first trial, move only the "short distance" stated in the above quotation, it was, therefore, impossible to move

any other vessel farther, by means of steam, I may heed the clamour they raise about my proposition not being practicable through a long line of tunnel.

Until then, I can consider it only as a proof of their knowledge being on a par with the wisdom of that most learned opponent of Galileo's theory, that day and night are occasioned by the revolution of our planet on its axis, who, in answer to the query, "How then is it that the sun gets back to and always rises in the east of a morning?" replied, that he went back by night, when nobody could see him.

In concluding, I will endeavour to guard against a circumstance that may otherwise be injurious to me, by an observation. You will perceive that the evidences which I have quoted have been in existence six or seven years. How then, it may be inqured, is it that a method which is spoken of so highly as those evidences speak of this mode of conveyance, should have remained seven years without having been put into actual practice, or brought any nearer to that consummation than it was when those documents were written?

During the many years which elapsed between the period of Columbus's first proposing to Ferdinand and Isabella the discovery of America, and their actually setting him afloat to do it, he sent his brother Bartholomew to England, to lay the proposition before our Seventh Henry, who, he expected, would entertain it. Henry did so; and would have possessed England of the southern more firmly than she afterwards became possessed of the northern half of America, but for the disaster which prevented Bartholomew Columbus from approaching him, till Isabella had agreed with, and dispatched Columbus himself.

"In his voyage to England," says the historian of America, "Bartholomew Columbus had been so unfortunate as to fall into the hands of pirates; who, having stripped him of every thing, detained him a prisoner for several years."

Circumstances which, morally speaking, are *exactly* similar to this captivity and imprisonment of Bartholomew Columbus—excepting that they failed in compelling me to sign away the patent rights, to wrest which from me they were instituted—have equally hindered me.

As relates to myself, I have no desire to obtrude the details of the cruel oppression and injustice practised upon me, on any one.

But with respect to the subject I advocate, I am most anxious that the whole world should know that I court the *fullest* inquiry, and am ready to answer *every* question.

As one proof of this, and to shew that there is nothing which I need to blush for, any more than Bartholomew Columbus had cause to blush for being imprisoned by the pirates, I beg to direct your attention to the annexed copy of the Petition I presented to Parliament; of which only an extract is given in page 19. Soliciting the favour of your perusing it, I have the honour to be,

My Lords, and Gentlemen,

Your very obedient,

And most humble Servant,

JOHN VALLANCE.